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Addressing the impact of disasters on public health infrastructure and noncommunicable diseases

Benjamin J. Ryan
Bachelor of Science in Environmental Health
Master of Public Health

25 June, 2018

A thesis submitted
for the degree of Doctor of Philosophy

In the College of Public Health, Medical and Veterinary Sciences
James Cook University, Australia

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Student Biography

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Benjamin J. Ryan joined the Daniel K. Inouye Asia-Pacific Center for Security Studies (APCSS), Honolulu, United States of America, from Queensland Health, Australia, in August 2017. His areas of focus at APCSS are community resilience, disaster management, environmental security, global health and regional disaster coordination.

He has led workshops, training, lectures and activities in his areas of focus across the Asia-Pacific, Europe and North America. This includes representing the United States Government in engagement with the Association of Southeast Asian Nations (ASEAN) on humanitarian assistance and disaster relief, responding to natural disasters and disease outbreaks (including Ebola and Dengue), leading health preparations for the G20 Finance Ministers meetings in Australia, managing projects in Indigenous communities and facilitating health services for asylum seekers. He has worked at local, state, federal and executive levels of government in Australia.

Mr. Ryan's PhD research has focused on developing strategies for reducing the impact of disasters on people with noncommunicable diseases. He has completed a Master of Public Health at the University of Wollongong, Australia, and a Bachelor of Science in Environmental Health at Griffith University, Australia, where he received an award for academic excellence.

He has collaborated with researchers in Australia and Japan to improve evacuation centre standards for vulnerable groups and supported the United Nations Office for Disaster Risk Reduction Global Education and Training Institute (UNISDR-GETI) efforts to implement the *Sendai Framework for Disaster Risk Reduction 2015-2030*. Mr. Ryan also assisted the World Health Organization's review of the disaster risk management for health fact sheet on noncommunicable diseases.

Mr. Ryan has: published 11 peer-reviewed articles, two guidelines and a textbook chapter; delivered 17 conference presentations (ten international, two national, one state and four regional); facilitated seven disaster risk reduction workshops for UNISDR-GETI; and conducted seven media interviews relating to noncommunicable diseases, disaster management and the environmental health aspects of disasters.

Acknowledgements

I would like to sincerely thank the many people who have provided encouragement, guidance and support throughout this research. The people I wish to express my gratitude to expands beyond this acknowledgements section, however, there people that I would like to thank individually.

To my wife Peta and children Lara, Hudson and Ella. Without your patience and support, I would not have been able to complete this research and be where I am today. You have kept me in touch with the "real world" while I have been focused on this research. Your love and support mean the world to me and has kept me rational during the challenging times of this study. For being there for me, a big thank you!

To my parents, John and Robyn. Your ongoing support, encouragement, guidance and opportunities you made possible over the years have allowed me to be where I am today. I am forever grateful for the sense of self-confidence, belief and resilience you have instilled in me. I hope completion of this research and awarding of a PhD is in some small way as joyful for you as it is for me.

My primary advisor Associate Professor Richard Franklin. I would like to express my gratitude and thanks for your guidance, advice and commitment to this research. You have definitely enriched the research experience and I now see how all the queries, challenges and tests along the journey were necessary. Sincerely, thank you for all your support, leadership and vision. It has been a great journey and without you, I would not be here today.

To "Uncle Skip" Professor Frederick Burkle Jr. mentor and advisor. It has been an honour having your incredible insights, expertise, leadership and support throughout this research. You have made this journey a truly rewarding experience. Thank you for guiding the research topic, enthusiasm to share the findings and connecting me with other researchers and professionals across the world. You are truly an inspirational mentor and humanitarian leader.

Associate Professor Peter Aitken. I greatly appreciate you sharing your knowledge, experience, passion for disaster health and willingness to help translate this research into action. I have truly valued not only your academic support but also the professional advice you have provided. Without you, I would not have completed this PhD. Thank you.

Professor Peter Leggat. You were with me at the beginning of the PhD journey and through all the milestones, challenges and tests along the way. Thank you for sticking with me. I greatly appreciate the time you made available, contributions and willingness to support the research. It was great to have you involved.

To Dr. Erin Smith. Thank you for your assistance, particularly helping me at the start of the research and sharing your knowledge, expertise and contacts in the field of disaster health. I would not have navigated the challenges and tests along the way without your ongoing guidance and enthusiasm. I am honoured to have you as part of this research.

Associate Professor Kerrianne Watt. Thank you for your assistance developing and enriching the methodology used for this research. It was a privilege having you involved in this project. I greatly appreciate your contributions.

The late Professor Ross Spark. Without your encouragement and advice, I would not have contemplated undertaking PhD studies. Also, thank you for the encouragement to start and complete a Master of Public Health, which led me into postgraduate studies.

Thank you to the Cohort Doctoral Studies Program at James Cook University, particularly Dr Melissa Crowe. Without your support, workshops, writing retreats and nurturing throughout the studies, I would not have been able to complete this research.

Thank you to the Australian Centre for Health Services Innovation (AusHSI), Toowoomba Hospital Foundation and Cunningham Centre, Far North Queensland Hospital Foundation, Higher Degree Research Enhancement Scheme at James Cook University and the Northern Queensland Primary Health Network. The funding and support you gave provided the confidence and mechanisms required to complete this research. I am truly grateful.

To the Cairns and Hinterland Hospital and Health Service, Queensland Health, Australia, my employer throughout the majority of the PhD journey. Thank you for your support, encouragement and willingness to give me time off to complete the studies.

Thank you to the Daniel K. Inouye Asia Pacific Center for Security Studies, United States of America, my employer at the time of submission. I am truly thankful for the encouragement, support and motivation you provided as I finalised the thesis.

Finally, the people with noncommunicable diseases and disaster service providers who participated in this project. Thank you for making the time available to participate. I truly hope the research findings capture your insights and recommendations.

Statement of the Contribution of Others

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	Advisors	• Prof Frederick Burkle, Harvard University • A/Prof Peter Aitken, James Cook University • Dr Erin Smith, Edith Cowan University • A/Prof Kerrianne Watt, James Cook University • Prof Peter Leggat, James Cook University
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	Editorial assistance (thesis)	• A/Prof Richard Franklin, James Cook University • Ms. Katharine Fowler, Copy Editor
Financial support	Research grants	• Infront Outback Grant, Toowoomba Hospital Foundation and Cunningham Centre in 2013 ($10,000 for focus groups, interviews and conference presentations).

		• Australian Centre for Health Services Innovation (AusHSI) in 2013 ($10,000 for focus groups, interviews and conference presentations). • AusHSI in 2014 ($10,000 for focus groups, interviews and conference presentations). • FNQ Hospital Foundation Research Grant in 2016 ($3,000 for modified Delphi process). • Higher Degree Research Enhancement Scheme, James Cook University in 2016 (presentation at World Association of Emergency Medicine Congress, Toronto, Canada)
	Research costs/support	• James Cook University doctorate allowance • Cohort Doctoral Studies Program at James Cook University (travel to attend study blocks)
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	Transcription	• Amanda Cairns, Cairns Transcription Services
Infrastructure	External to James Cook University	• Cairns and Hinterland Hospital and Health Service • Department of Health (Queensland)

Abstract

Worldwide there has been a “disease transition” to noncommunicable diseases due to population aging, increasing obesity and decreasing physical activity. This combined with an increasing frequency of natural disasters has created challenges for disaster and health systems. Natural disasters can and do damage public health infrastructure such as services and supplies, resulting in acute exacerbation of noncommunicable diseases. To reduce the risk, this research explored the impact of cyclone, flood and storm related disasters on public health infrastructure and the management of noncommunicable diseases in Queensland, Australia, and used the findings to develop mitigation strategies. Data was collected, analysed and integrated over three sequential phases: literature reviews; focus groups and interviews; and a modified Delphi process. People with noncommunicable diseases found to be at greatest risk were those: with cardiovascular, respiratory and renal diseases; undergoing cancer treatment; and with unstable diabetes; and mental health conditions. There were 31 mitigation strategies identified across 12 public health infrastructure themes. Specific strategies include: designated primary healthcare hubs post disaster; streamlining processes for patients to access medication after a disaster; the need for water treatment plants to have back-up power; good hygiene practices implemented at evacuation centres; and consistent and clear messages about where people can go for assistance after a disaster. These findings informed development of a conceptual framework and options for implementing mitigation strategies to sustainably minimise the impact of disasters on people with noncommunicable diseases.

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Preface

Executive Summary

Background

Worldwide there has been a "disease transition" to noncommunicable diseases due to a combination of population aging, increasing obesity, decreasing physical activity and environmental change. However, the traditional focus of disaster management has been on the management of immediate trauma and communicable diseases. This remains despite the actual risk of post disaster communicable disease outbreaks being low, particularly in developed countries. A breakdown in public health infrastructure reduces access to treatment, care and services for people with noncommunicable diseases, which may result in disease exacerbation, worsening prognosis or even death. This risk will continue, if not increase, due to a growing noncommunicable disease burden, climate change, deforestation and rapid urbanisation in flood plains and storm-prone coastal zones. This challenge has been recognised in the *Sendai Framework for Disaster Risk Reduction 2015-2030*, where item 30(k) requests that people with chronic diseases (noncommunicable diseases) be included in the design of disaster policies and plans.

Aim and objectives

The aim was to investigate the impact of cyclone, flood and storm related disasters on public health infrastructure and the management of noncommunicable diseases, and develop strategies for mitigating the risks identified. The objectives included: investigating the impact of cyclone, flood and storm related disasters on public health infrastructure and noncommunicable diseases; exploring links between noncommunicable diseases and public health infrastructure, and how this can be impacted by disasters; identifying modifiable risks; and developing strategies for mitigating the risks identified.

Methods

A sequential mixed methods exploratory approach (qualitative followed by quantitative) was used to complete the research in Queensland, Australia. This location was selected due to the risk of cyclone, flood and storm related disasters and burden of noncommunicable diseases. The qualitative component included three literature reviews, and six focus groups and

42 interviews with 105 participants. A thematic analysis was conducted to analyse the qualitative data. A modified Delphi process was conducted through three phases: questionnaire (n=14) to recommend mitigation strategies for the survey phase; workshop (n=18) to explore questionnaire results; and survey (n=552) to rank and prioritise mitigation strategies. Descriptive statistics, bivariate and logistic regression modelling were used to analyse survey data. The participants were people with noncommunicable diseases and disaster service providers. Participants for the questionnaire and workshop phases were disaster health experts. The data was sequentially analysed and triangulated to develop mitigation strategies.

Results

Cyclone, flood and storm related disasters can breakdown public health infrastructure, resulting in noncommunicable disease exacerbation, worsening prognosis or even death. People at greatest risk are those with underlying cardiovascular and respiratory diseases, undergoing cancer treatment, with unstable diabetes and mental health conditions, and with renal diseases.

Public health infrastructure for the disaster setting was defined and described as "the workforce, equipment, supplies, and protection services required to maintain the health and wellbeing of individuals and the community". Access to water was identified as the most important public health infrastructure theme for reducing the impact of disasters on treatment, care and services for people with noncommunicable diseases. Once water supply issues are resolved, the remaining forms of public health infrastructure and the associated mitigation strategies should be progressively addressed.

There were 31 mitigation strategies identified across 12 public health infrastructure themes. The mitigation strategies are interrelated via public health infrastructure theme and for this reason if one component fails the health and wellbeing of people with noncommunicable diseases will be at risk. Specific strategies identified included: designated primary healthcare hubs post disaster; streamlining processes for patients to access medication after a disaster; the need for water treatment plants to have back-up power; good hygiene practices implemented at evacuation centres; and consistent and clear messages about where people can go for assistance after a disaster.

Conclusion

Cyclone, flood and storm related disasters can breakdown public health infrastructure resulting in noncommunicable disease exacerbation, worsening prognosis or even death. People at greatest risk are those with underlying cardiovascular and respiratory diseases, undergoing cancer treatment, unstable diabetes and mental health conditions, and with renal diseases. To reduce this risk post disaster, providing access to water should be first priority followed by implementation of the mitigation strategies related to communication, sanitation, workforce, supplies, power, equipment, physical structure, services, governance, prevention and finance. Implementation requires a collaborative governance approach due to the range of sectors, organisations and disciplines involved. Achieving this would not only support implementation of the *Sendai Framework for Disaster Risk Reduction 2015-2030* but also provide a sustainable approach towards reducing noncommunicable disease mortality and morbidity before, during and after a disaster.

Statement of Contribution

Contribution of research

The research has enhanced the profile of noncommunicable diseases (NCD) in the disaster setting, provided a guide for health system disaster preparedness and increased awareness of the *Sendai Framework for Disaster Risk Reduction 2015-2030* (Sendai Framework). How this has been achieved is described in the following.

NCDs disaster profile

The profile and needs of people with NCDs before, during and after a disaster has been enhanced through inclusion of disaster service providers in the research at all levels of government in Queensland, Australia. This included focus groups, interviews and the modified Delphi process. This has been complemented by: six peer-review publications[1-6]; 13 conference presentations directly related to this research (seven international, two national, one state and three regional); four media interviews; four other publication opportunities[7-10]; four other conference presentations (three international and one regional); and three other media opportunities. For further information on the publications, presentations and media opportunities associated with the research see Achievements.

Health system disaster preparedness

The research has helped the health system prepare for disasters by providing mitigation strategies and an understanding of the perceived challenges faced by people with NCDs across the disaster cycle. This has been complemented by: engagement with disaster health experts across Queensland during focus groups, interviews and the modified Delphi process; contributing as an author to the text *Disaster Health Management: Primer for Students and Practitioners*[7], which included contributions from a range of disaster management experts in Australasia; and being part of an expert advisor team to develop guidelines for the Australian Diabetes Educators Association[9].

This contribution is further demonstrated by recent preparations and response to Severe Tropical Cyclone Debbie in March 2017. This included media statements about people with NCDs needing to prepare medications for up to seven days and, for the first-time, health

assessments of evacuees into Cairns. This has been complemented by assisting the World Health Organization's review of the disaster risk management for health fact sheet on NCDs.

Sendai Framework

The research direction and results from the literature review that analysed the impact of Severe Tropical Cyclone Yasi on PHI and the management of NCDs was shared with those drafting the *Sendai Framework for Disaster Risk Reduction 2015-2030* (Sendai Framework).[2] This was one of many publications used to help include chronic diseases (also known as NCDs) as item 30(k) in the Sendai Framework, which recommends people with NCDs be part of policy design and plans to manage risks before, during and after disasters, including access to life-saving services.[11,12] Also, during the data collection phases, publications and presentations there has also been active promotion of the Sendai Framework.

Achievements

The research has enhanced the disaster and health systems ability at local, state, national and international levels to maintain treatment, care and services for people with NCDs before, during and after a disaster. This has been achieved through six peer-review publications[1-6]; 13 conference presentations directly related to this research (seven international, two national, one state and three regional); four media interviews; four other related publication opportunities[7-10]; four other conference presentations (three international and one regional); and three related media opportunities. An overview is provided in the following along with the United Nations Office for Disaster Risk Reduction's Global Education and Training Institute (UNISDR-GETI) training/workshops delivered and professional development during the PhD journey.

Peer-reviewed publications

1. **Ryan B**, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2018). Ranking and prioritizing strategies for reducing mortality and morbidity from noncommunicable diseases post disaster. *International Journal of Disaster Risk Reduction*. Vol 27:223-23. Impact factor 1.603 (Thomson Reuters 2017); Indexing EBSCOhost, Elsevier BV, Gale, National Library of Medicine, Ovid, ProQuest and Thomson Reuters; Google Scholar citations nil. (Chapter 5 and Appendix F)

Author contributions: Ryan led the design, research and write up. Aitken helped organise the questionnaire and workshop phase with the disaster health expert group. Franklin assisted with the questionnaire and workshop, and guided the research design, reviewed the results and edited the paper prior to submission. Burkle, Aitken, Smith, Watt and Leggat provided advice on the methodology and used their expertise to review the manuscript.

2. **Ryan B**, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2017). The role of environmental health in understanding and mitigating post-disaster noncommunicable diseases: The critical need for improved multidisciplinary solutions. *Journal of Environmental Health*. Vol 80(5):38-50. Impact factor 0.927 (Thomson Reuters 2017); Indexing CABI, EBSCOhost, Elsevier BV, Gale, H.W. Wilson, International Atomic Energy Agency, National Library of Medicine, OCLC, Ovid, Pan American Health Organization, ProQuest, Safe Publications, Thomson Reuters and U.S. National Library of Medicine; Google Scholar citations 3. (Section 4.2 and Appendix D)

   Author contributions: Ryan led the design, research and write up. Franklin guided the research design, reviewed the results and edited the paper prior to submission. Burkle, Aitken, Smith, Watt and Leggat provided advice on the methodology and used their expertise to review the manuscript.

3. **Ryan B**, Franklin RC, Burkle Jr. FM, Aitken P, Smith E, Watt K, Leggat P (2016). Reducing Disaster Exacerbated Noncommunicable Diseases Through Public Health Infrastructure Resilience: Perspectives of Australian Disaster Service Providers. *PLOS Currents: Disasters*. 2016 (Dec 21). Edition 1. Impact factor not available; Indexing PubMed and Scopus; Google Scholar citations 15. (Section 4.3 and Appendix E)

   Author contributions: Ryan led the design, research and write up. Franklin guided the research design, reviewed the results and edited the paper prior to submission. Burkle, Aitken, Smith, Watt and Leggat provided advice on the methodology and used their expertise to review the manuscript.

4. Ryan B, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2015). Identifying and describing the impact of cyclone, storm and flood related disasters

on treatment management, care and exacerbations of noncommunicable diseases and the implications for public health. 2015 (7). *PLOS Currents: Disasters*. Impact factor not available; Indexing PubMed and Scopus; Google Scholar citations 14. (Section 3.4 and Appendix C)

Author contributions: Ryan led the design, research and write up. Franklin guided the research design, reviewed the results and edited the paper prior to submission. Burkle, Aitken, Smith, Watt and Leggat provided advice on the methodology and used their expertise to review the manuscript.

5. **Ryan B**, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2016). Defining, describing and categorizing public health infrastructure for cyclone, flood and storm related disasters. *Disaster Medicine and Public Health Preparedness*. Vol 1:1-13. Impact factor 1.354 (Thomson Reuters 2017); Indexing Adis International Ltd., CABI, EBSCOhost, Elsevier BV, National Library of Medicine, Thomson Reuters and U.S. National Library of Medicine; Google Scholar citations 7. (Section 3.3 and Appendix B)

   Author contributions: Ryan led the design, research and write up. Franklin guided the research design, reviewed the results and edited the paper prior to submission. Ryan, Franklin, Burkle and Aitken conducted the interdependency ranking process. Burkle, Aitken, Smith, Watt and Leggat provided advice on the methodology and used their expertise to review the manuscript.

6. **Ryan B**, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2015). Analyzing the impact of Severe Tropical Cyclone Yasi on public health infrastructure and the management of noncommunicable diseases. *Prehospital and Disaster Medicine*. Vol 30(1):1-10. Impact factor 1.03 (ResearchGate 2015); Indexing ESCI, National Library of Medicine, Scopus, OCLC, Ovid, Pan American Health Organization, ProQuest, Safe Publications, Thomson Reuters and U.S. National Library of Medicine; Google Scholar citations 14. (Section 3.2 and Appendix A)

   Author contributions: Ryan led the design, research and write up. Franklin guided the research design, reviewed the results and edited the paper prior to

submission. Burkle, Aitken, Smith, Watt and Leggat provided advice on the methodology and used their expertise to review the manuscript.

Conference presentations

1. **Ryan B**, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2017). Reducing noncommunicable disease exacerbation after a disaster. 20th World Congress on Disaster and Emergency Medicine, Toronto, Canada, 25 April 2017.
2. **Ryan B**, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2016). Disasters and noncommunicable diseases: lessons learned and questions going forward. Environmental Health Australia Darling Downs and South West Group conference, 29 July 2016.
3. **Ryan B**, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2016). Strategies for reducing disaster exacerbated noncommunicable diseases. Environmental Health Australia Northern Group conference, 21 May 2016.
4. **Ryan B**, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2015). An environmental health perspective on mitigating the impact of cyclone, flood and storm related disasters on people with noncommunicable diseases. Global Environmental Health Faculty Forum, Coimbra, Portugal, 24 September 2015.
5. **Ryan B**, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2015). Exploring impact of cyclone, flood and storm related disasters on public health infrastructure and the management of noncommunicable diseases. ADS ADEA Annual Scientific Meeting, Adelaide, Australia, 26 August 2015.
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9. **Ryan B**, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2015). Challenges facing disaster management and health security systems from noncommunicable diseases. Pacific Risk Management Conference, Honolulu, Hawaii, 25 March 2015. (invited)
10. **Ryan B**, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2014). Environmental Health and Disaster Management future challenges: Noncommunicable Diseases. Environmental Health Australia State Conference, Toowoomba, Australia, 9 September 2014.
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Media

1. 26 August 2015 – ABC news, Adelaide, Australia. Television interview regarding the impact of disasters on people with noncommunicable diseases.
2. 29 April 2015 – ABC Far North. Interview regarding paper titled “Investigating the impact of Severe Tropical Cyclone Yasi on public health infrastructure and the management of noncommunicable diseases”.

3. 19 March 2015 – Australian Associated Press published a summary of a paper covering the impact of Severe Tropical Cyclone Yasi on public health infrastructure and management of noncommunicable diseases.
4. September 2014 – Feature interview by Australian Centre for Health Service Innovation about research direction.

Other publication opportunities due to PhD research

1. **Ryan B** & Franklin R (2017). Chapter 2: Disaster Trends and Impact. Disaster Health Management: Primer for Students and Practitioners. Routledge Publications. Book chapter.
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1. **Ryan B**, Burns P & Bhatia S (2017). Presentation – Integrating the Sendai Framework into primary health networks: an Australian perspective. 20th World Congress on Disaster and Emergency Medicine, Toronto, Canada, 25 April 2017.
2. Kako M, Takada Y, Steenkamp M, Arbon P & **Ryan B**. Presentation – Discovering best practice for the implementation of evacuation centres for vulnerable populations: findings from a Japanese pilot study Best Practice Standards? 20th World Congress on Disaster and Emergency Medicine, Toronto, Canada, 25 April 2017.
3. **Ryan B** (2015). Reducing disaster risk through environmental health capacity building. A regional experience, lessons learned and future priorities. International Environmental Health Conference, Kuching, Malaysia, 27 October 2015. (key note)
4. **Ryan B** (2013). Environmental Health and Disaster Management, Environmental Health Worker Workshop, Cairns Queensland, May 2013. (invited)

Other related media

1. 24 March 2017 – Cairns Post. Media statement about the need for people to have arrangements in-place to maintain care during and after Severe Tropical Cyclone Debbie.
2. 8 August 2015 – Cairns Post. Interview about the impact of Ravenshoe Café Explosion.
3. 23 March 2015 – ABC Tropical North. Interview regarding disaster planning for chronic diseases.

UNISDR-GETI training/workshops delivered due to PhD and professional experience

- Training of Trainers for utilising the Sendai Monitor to develop action plans for disaster risk reduction, New Delhi, India, 18 to 20 December 2017.
- Implementation of the Sendai Framework for the health sector and introduction to the Hospital Safety Index, Brisbane, Australia, 15 and 16 June 2017.
- Urban Risk Reduction and Resilience: Capacity Development for Making Cities Resilient to Disasters, Cairns, Australia, 12 and 13 June 2017.

- Implementation of the Sendai Framework: Development of Risk Reduction Strategies and Plans for the Environment and Health, Baylor University, Waco, Texas, USA, 11 and 16 May 2017.
- Disaster Risk Reduction Workshops for Health Care, Cairns, Townsville and Mackay, Australia, 7 to 10 November 2016.

Development during PhD journey

- Offered and accepted Associate Professor role with the Daniel K. Inouye Asia Pacific Center for Security Studies, Honolulu, Hawaii, USA.
- An increased understanding of qualitative and quantitative research methods
- Qualitative Research Methods, James Cook University, April 2013.
- Writing publications, text books chapters and funding applications.
- Enhanced writing, presentation and media skills.
- Development of a strong network of domestic and international collaborators,
- Led to the following opportunities:
    - United States Government representative supporting the ASEAN Plus Expert Working Group on Humanitarian Assistance and Disaster Relief.
    - Assisting the World Health Organization's review and update the Disaster Risk Management for Health Fact Sheet on Noncommunicable Diseases.
    - Delivering a lecture on NCD control and prevention in humanitarian crises at the Health and Humanitarian Action in Emergencies Course for the Center for Excellence in Disaster Management and Humanitarian Assistance at James Cook University, Cairns, Australia, December 2017.
    - Visiting faculty for a Global Health and Environmental Aspects of Disaster Risk Reduction graduate course at Baylor University, Waco, Texas USA, May 2017.
    - Attendance at city resilience scorecard workshop, UNISDR Global Education and Training Institute (UNISDR-GETI), April 2017.
    - Endorsement as trainer for delivery of UNISDR-GETI materials.
    - Workshop for Implementation of the Sendai Framework: Development of Risk Reduction Strategies and Plans, UNISDR-GETI, April 2016.
    - Environmental Health Training in Emergency Response (EHTER), Local Public Health Institute of Massachusetts, Boston USA, April 2012.

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Abbreviations

Abbreviation	Name
ADEA	Australian Diabetes Educators Association
ADF	Australian Defence Force
ASEAN	Association of Southeast Asian Nations
CCC	Australian Government Crisis Coordination Centre
COAG	Council of Australian Governments
COPD	Chronic obstructive pulmonary disease
DACC	Defence Assistance to the Civil Community
DDC	District Disaster Coordinator
DDMG	District Disaster Management Group
EMA	Emergency Management Australia
ERC	Emergency Relief Coordinator
HC	Humanitarian Coordinator
HEOC	Health Emergency Operation Centre
HHS	Hospital and Health Service
IGEM	Inspector-General of Emergency Management
LCCSC	Law, Crime and Community Safety Council
LDMG	Local Disaster Management Group
NCD	Noncommunicable disease
NDO	Natural Disaster Organisation
NGO	Non-government Organisation
OCHA	Office for the Coordination of Humanitarian Affairs
PARIHS	Promoting Action on Research Implementation in Health Services
PHI	Public Service Infrastructure
PRISMA	Preferred Reporting Items for Systematic Review and Meta-Analyses

PHN	Primary Health Network
QDMA	Queensland Disaster Management Arrangements
QDMC	Queensland Disaster Management Committee
QPS	Queensland Public Service
RDRTF	Renal Disaster Relief Task Force
SCDO	State Counter Disaster Organisation
SDCC	Queensland State Disaster Coordination Centre
SDG	Sustainable Development Goals
SES	State Emergency Service
SHECC	State Health Emergency Coordination Centre
SPSS	Statistical Package for the Social Sciences
UNICEF	United Nations Children's Fund
UNISDR	United Nations Office for Disaster Risk Reduction
UNISDR-GETI	United Nations Office for Disaster Risk Reduction Global Education and Training Institute
U.S.	United States
USA	United States of America
WHO	World Health Organization

Chapter 1 Introduction

The increasing frequency of natural disasters and worldwide "disease transition" to noncommunicable diseases (NCD) has created challenges for disaster and health systems. Natural disasters can and do damage public health infrastructure (PHI) including sanitation, services, supplies and water, which can contribute to acute exacerbation of NCDs. To help reduce the risk, this research explored the impact of cyclone, flood and storm related disasters on PHI and the management of NCDs in Queensland, Australia, and used the findings to develop mitigation strategies. A combination of qualitative and quantitative research methods was sequentially used and included: literature reviews, focus groups and interviews, and a modified Delphi process (questionnaire, workshop and survey). This chapter presents the background and rationale for this PhD research. This includes the aim and objectives, thesis structure and definitions for disaster, PHI and NCD. Background information on the research problem is provided along with a description of disaster management systems and their evolution internationally, in Australia, across Queensland and in the health sector.

1.1 Aim of the project

The aim was to investigate the impact of cyclone, flood and storm related disasters on PHI and the management of NCDs, and develop strategies for mitigating the risks identified.

1.1.1 *Research questions*

- ***What*** is the impact of cyclone, flood and storm related disasters on PHI and NCDs?
- ***How*** does a breakdown in PHI impact on the management of NCDs?
- ***How*** can this impact be potentially mitigated in the future?

1.1.2 *Objectives*

- To investigate the impact of cyclone, flood and storm related disasters on PHI and NCDs.
- Explore the links between NCDs and PHI, and how this can be impacted by cyclone, flood and storm related disasters.

- Identify modifiable risks that will reduce the impact of cyclone, flood and storm related disasters on the health and wellbeing of people with NCDs.
- Develop strategies for mitigating the risks identified.

1.2 Thesis structure

The Thesis has seven chapters, including introduction, methodology, three sequential results chapters (encompassing six peer-reviewed publications), discussion, conclusion and appendices. This chapter (introduction) provides the background information required to understand the context, definitions used for the research and the evolution of disaster systems. The methodology chapter outlines the theoretical paradigm, research strategies and methods for data collection and analysis. The results in chapters three, four and five sequentially present the findings from the literature reviews, focus groups, interviews and the modified Delphi process (questionnaire, workshop and survey). The discussion chapter integrates the research findings and recommends future directions. The final chapter (conclusion) provides a summary of the research findings.

1.3 Key definitions

1.3.1 *Disaster*

The definition of disaster has been widely discussed and debated with many considering the pioneer Canadian, Samuel Henry Prince.[1] He began the formal study of disasters with his dissertation on Canada's 1917 ship explosion in the harbour of Halifax, Nova Scotia.[2] His pioneering study and sociological exploration of the effects of disasters stimulated further empirical and theoretical research throughout the 1930s, 40s, and 50s, resulting in a shift in the way disasters were defined.[1] Instead of referring to disasters as a primarily physical agent, definitions and descriptions began to emphasise the social impact including how they affected health, social, cultural and economic infrastructure.[3]

Throughout the 1960s definitions and concepts of disasters were further explored, continuing a shift from the cause to sociological aspects and impacts.[4,5] This changed in the 1970s, when Henry Quarantelli pushed for the international recognition of disaster research as an academic speciality, which triggered emergence of new models for approaching disasters based on the

analysis of communities.[6,7] The next 30 years of research continued to engage academics from a wide variety of disciplines to examine nature, definition and concepts of disasters.

While the greater interest in disasters has led to more reflection and interpretation, a single definition defining the phenomena of disaster still is elusive, with most disciplines proposing definitions that reflect their individual interests.[1] Definitions of disaster also can be compared at international and national levels, where organisations develop their own working definitions of disaster, which, not unexpectedly, reflect the professional background of the definer and the context of their work, studies, or research.[1,3,8] The variances at international, national and discipline levels are described in the following along with the definition used for the study.

1.3.1.1 Internationally

The United Nations Office for Disaster Risk Reduction (UNISDR) defines a disaster as "a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources".[9] Under this definition, disaster impacts may include loss of life, injury, disease and other negative effects on human physical, mental and social wellbeing, together with damage to property, destruction of assets, loss of services, social and economic disruption and environmental degradation.[9]

The World Health Organization (WHO) provides an alternative definition and describes a disaster as "a term describing an event that can be defined spatially and geographically, but demands observation to produce evidence. It implies the interaction of an external stressor with a human community and it carries the implicit concept of non-manageability".[10] The International Federation of Red Cross and Red Crescent Societies define a disaster as "a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's ability to cope using its own resources. Though often caused by nature, disasters can have human origins".[11]

1.3.1.2 Australia

The Australian Emergency Management Glossary (pp. 32-33) defines a disaster as "a serious disruption to community life which threatens or causes death or injury in that community

and/or damage to property beyond the day-to-day capacity of the prescribed statutory authorities and which requires special mobilisation and organisation of resources other than those normally available to those authorities".[12] In the state of Queensland, the *Disaster Management Act 2003* defines a disaster in section 13 (p.14) as a "a serious disruption in a community, caused by the impact of an event that requires a significant coordinated response by the state and other entities to help the community recover from the disruption".[13] A serious disruption is considered a loss of human life, or illness or injury to humans; or widespread or severe property loss or damage; or widespread or severe damage to the environment.[13]

1.3.1.3 Discipline Specific

1.3.1.3.1 Economic

From an economic perspective a disaster can be defined as an event that disrupts the functions of the economic system, with a significant negative impact on assets, production factors, output, employment or consumption.[14] The World Bank refers to a disaster as a hazard's effect on society due to a combination of exposure and vulnerability.[15] In this instance a hazard is a natural process or phenomenon with adverse effects, differing in severity, scale, and frequency, and are often classified by cause (such as hydro-meteorological or geological).[15]

1.3.1.3.2 Engineering

The World Federation of Engineering Organizations defines a disasters as the "…consequence of natural hazards such as earthquakes, tsunamis, floods, droughts, cyclones, typhoons or hurricanes, landslides, forest fires, and volcanic eruptions; they are also caused by manmade incidents such as industrial accidents, power cuts, and air-pollution".[16] According to a study by Vallero & Letcher (2012) most engineering leaders agree disasters are low-probability events with high-value consequences and problems become disasters when risks that are not properly managed resulting in significant physical damage to human life, ecosystems, and materials.[17]

1.3.1.3.3 Medical

The World Association for Disaster and Emergency Medicine refers to a disaster as an event resulting in casualties that overwhelm the healthcare system in which the event occurs.[18] This definition refers to the medical system and is inclusive of doctors (for example, medical officer and physician), nurses, psychosocial professionals and other clinicians. A disaster can be from

a precipitous or gradual decline in the overall health status of a community with which it is unable to cope adequately.[18] A more focused definition is provided by Hogan and Burstein (2007, p. 2) refers to a disaster as a "…the number of patients presenting within a given time period are such that the emergency department cannot provide care for them without external assistance".[19] Disasters are not necessarily defined by the number of casualties, for example, a single-vehicle collision with three serious casualties may be a disaster for a small rural emergency department due to limited capacity to cope, however, this would not be the case for a large city hospital which has the workforce, services and capacity for such an incident.[20]

1.3.1.3.4 Public Health

The Center for Disaster Control and Prevention (United States of America) defines a disaster as "a serious disruption of the functioning of society, causing widespread human, material or environmental losses, that exceeds the local capacity to respond, and calls for external assistance".[21] According to this definition natural and man-made disasters can occur without warning; preventing them from resulting in major public health emergencies that require careful planning.[22] Public health emergencies have both a direct and indirect consequence on the health of a population when protective infrastructure (i.e. water, sanitation, shelter, food, and health) is absent, destroyed, overwhelmed, not recovered or maintained, or denied to populations.[23] The public health definition focuses on situations whose scale, timing, or unpredictability threatens to overwhelm routine capabilities.[24] The public health risks of disasters can include illness, physical injury, potential disease outbreaks, exacerbation of chronic illness, mental health issues and death.[21]

1.3.2 *Disaster definition of this research*

Despite the contrasting definitions, most describe a disaster as being a situation where the capacity of the local community and services to cope is exceeded and external assistance required. In this context, disasters can be caused by natural phenomena, such as cyclones, floods and storms, and the effects of climate change, or human-made and technological threats, such as terrorism, bioterrorism, and chemical, biological, radiological, or nuclear devices.[1] This combined with the study being conducted in the state of Queensland, Australia, has resulted in

the definition used in the Queensland *Disaster Management Act 2003* section 11 (pp. 4) being selected for the research. This is:

> *"A disaster is a serious disruption in a community, caused by the impact of an event that requires a significant coordinated response by the state and other entities to help the community recover from the disruption."*

1.3.3 *Noncommunicable Disease (NCD)*

NCDs also known as chronic diseases, are not passed from person to person.[25] They are long-lasting, placing great burden on patients, health services and fiscal systems.[26,27] There are four major groupings: cardiovascular diseases; cancers; chronic respiratory diseases; and diabetes.[28-30] These conditions account for 79% of NCD deaths globally and have common behavioural risk factors (smoking, physical inactivity, poor nutrition and harmful use of alcohol).[28,31,32] Minor groupings within NCDs include arthritis, obesity, mental health and renal conditions.[28,33-35] In Australia, NCDs cause approximately 90% of all deaths, account for 88% of the burden of disease and are responsible for 83% of recurrent health expenditure.[27,34]

The bulk of ill health, disability and premature death around the globe now generates from NCDs.[36,37] A combination of population aging, increasing obesity, decreasing physical activity, environmental change, rapid urbanisation and a reduction in communicable diseases has contributed to this epidemiological transition to NCDs.[38-44] However, the traditional focus of the disaster response has been on the management of immediate trauma and communicable diseases.[42] This focus remains despite the actual risk of post disaster communicable disease outbreaks being low, particularly in developed countries.[43-46] Those at greatest risk are patients undergoing cancer treatment, with underlying cardiovascular and respiratory diseases, unstable diabetes and mental health conditions, and renal diseases, especially if receiving dialysis.[43]

The NCD terms used to guide the research were cancer, cardiovascular diseases, diabetes, respiratory conditions and renal diseases.[43] These conditions are not only at greatest risk of exacerbation after a disaster but long-lasting and place great burden on patients, health services and fiscal systems.[26,27] A category of mental health conditions (for example, anxiety and depression) was included in the later phases of the research as this emerged as a condition of concern.

1.3.4 *Public Health Infrastructure (PHI)*

Prior to this study there had been little research into the definition of PHI in the context of people with NCDS and the field of disaster management. To define and describe this term PHI for the study, Ryan et al (2016) conducted a systematic literature review (Section 3.3 and Appendix B).[47] This research found PHI can be categorised into 13 thematical areas: communication; equipment; governance; physical structure; power; prevention; sanitation; service; supplies; surveillance; transport; water; and workforce. Based on this research the PHI definition developed by Ryan et al (2016, p.10) was used for the research:

> *"The workforce, equipment, supplies, and protection services required to maintain the health and wellbeing of individuals and the community."*

1.4 Background

The increasing NCD burden and frequency, intensity and severity of weather-related disasters (cyclones, floods and storms) has created a need to address the risk of these conditions exacerbating post disaster (Figure 1-1 and Table 1-1).[41,43,48] Almost three quarters of all NCD deaths, and 82% of people who die prematurely (before reaching 70 years of age), occur in low- and middle-income countries.[49] These conditions are also long-lasting and place a great burden on patients, health services and fiscal systems.[26,27] Meanwhile, floods and storms (includes cyclones) have accounted the majority of disasters (66%) and people affected by disasters (70%) from 1990 to 2015, and this threat is expected to only increase.[3] During this period the exposure of the population and infrastructure to weather-related disasters across the world also increased faster than vulnerability decreased.[50,51] Highlighting the need to focus disaster risk reduction strategies and resources on the most vulnerable.[42,43,48,51-54]

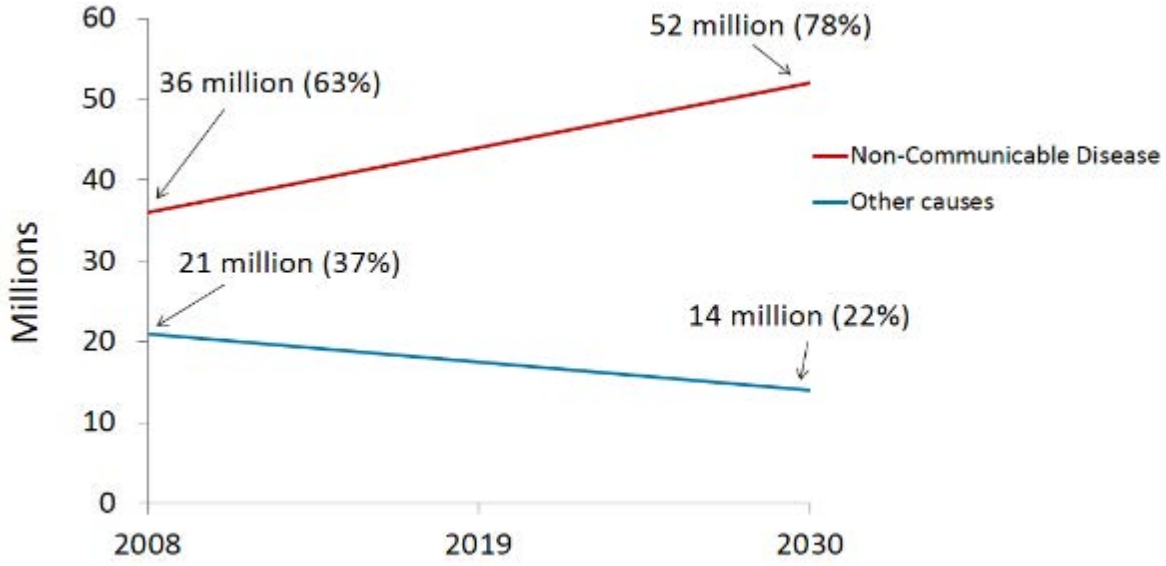

Figure 1-1 Projected trends of noncommunicable disease global deaths[55]

Table 1-1 Worldwide natural disasters 1990-2015[3]

Type of disaster (% of all disasters)	*Occurrence*	*Deaths*	*Injured*	*Total affected*
Flood (36.03)	3415	182,702	1,086,122	2,855,214,859
Storm (26.14)	2477	401,701	607,843	766,030,113
Epidemic (11.89)	1127	180,452	499,176	21,194,391
Earthquake/tsunami (7.43)	704	816,294	1,720,306	134,884,514
Extreme temperature (4.67)	443	166,415	1,964,945	99,098,929
Landslide (4.62)	438	22,009	4,424	6,103,932
Drought (4.15)	393	24,272	–	1,245,945,379
Wildfire (2.99)	283	1,770	5,928	5,598,133
Volcanic activity (1.48)	140	1,639	1,517	4,034,275
Insect infestation (0.32)	30	–	–	2,802,200
Mass movement: dry (0.27)	26	1,210	312	15,130
Impact (0.01)	1	–	1,491	301,491

The challenge of reducing the impact of disasters on people with NCDs has been recognised in the *Sendai Framework for Disaster Risk Reduction 2015-2030* (Sendai Framework). Item 30(k) recommends people with NCDs be part of policy design and plans to manage risks before, during and after disasters, including access to life-saving services.[50,56] This builds on the World

Health Organization (WHO) *Global Action Plan for the Prevention and Control of Noncommunicable Diseases – 2013-2020*.[57]

The World Economic Forum (WEF) also regularly ranks NCD risks on par with fiscal crisis and is only exceeded by the impact of an asset price collapse, or the increase in oil and gas prices.[58] The WEF highlights the strong links between NCDs and risks such as the fiscal crisis, underinvestment in infrastructure, and food, water and energy in security.[58] This is supported by a WHO paper, *Scaling up action against noncommunicable diseases: How much will it cost*, which details concern about the escalating global burden of NCDs, such as cardiovascular diseases, cancer, diabetes and chronic respiratory diseases, not being just an epidemiological issue but an economic one.[59]

Disasters can breakdown PHI and ongoing protections.[41-43,60-66] The result is an increased risk of acute exacerbation of NCDs, worsening long-term prognosis and even death.[43,67] The people with NCDs at greatest risk are those with underlying cardiovascular and respiratory diseases, undergoing cancer treatment, unstable diabetes and renal diseases.[41,43,61,68-72] This risk is anticipated to continue, if not increase, due to climate change and rapid unsustainable urbanisation in flood plains and storm-prone coastal zones.[50,73-75]

Historically NCDs have been seen as a high-income country problem, however, they now account for a very large burden of both mortality and morbidity in low and middle-income countries.[76] Lower-income countries generally have lower capacity for the prevention and control of NCDs, meanwhile, high-income countries are nearly four times more likely to have the required services covered by health insurance.[77] People in low and middle-income countries are likely to have access to a doctor and hospital services for acute conditions, however, they often have restricted access to ongoing treatment, care and services for NCDs.[78] The result is an increased risk of poorly managed NCDs and if this is the situation prior to a disaster, the likelihood of poor health outcomes post event increases.[44] This combined with the risk of acute care becoming comprised demonstrates the threat disasters pose to people with NCDs in low, middle and high income countries, for example, orthopaedic surgery is at much higher risk when a patient has poorly controlled cardiovascular disease.[47,79]

The health focus before, during and after a disaster has traditionally been on communicable diseases and immediate trauma. However, the actual risk is low, particularly in developed

countries.[46] A combination of population aging, increasing obesity, decreasing physical activity, environmental change and reduction in communicable disease in populations across the world has contributed to a "disease transition" to NCDs.[25,38,39,41] This transition poses a new challenge for disaster management and health systems, especially when PHI is destroyed, inaccessible or damaged, because access to treatment, care and services is often jeopardised, which can result in disease exacerbation, worse long term prognosis or even death.[41-44,60-65]

When PHI and social protections are not recovered or rehabilitated in a timely manner, or are destroyed or denied to vulnerable populations, a major and sustained "public health emergency" may occur.[80] For example, there was a 47% increase in mortality and morbidity one year after Hurricane Katrina.[53] During the event, 33% of people exhibited symptoms of chronic disease exacerbation when arriving at shelters and one year after Hurricane Katrina there was a 33% reduction in cancer treatment services.[43,70,81] Other examples include: 19% increase in cancer related deaths in the 12 months after Hurricane Iniki (1992) and during the weeks after four hurricane's in Florida (2004)[82,83]; diabetes accounting for 5% of excess deaths after the four Hurricane's in Florida[81,84]; and in the 30 days after Hurricane Sandy (2012), cardiac incidence increased by 22% and mortality by 31%.[85]

There was also increased indirect mortality in the three months after the 2011 Great East Japan Earthquake, primarily due to NCDs.[86] Uchimura et al (2014) found that for people over 60 years of age the mortality rate increased by 33% for those with cerebrovascular diseases, 37% with heart diseases (excluding hypertension), 54% with Chronic Obstructive Pulmonary Disease (COPD), 41% if on dialysis and 48% for endocrine, nutritional and metabolic diseases. The mortality rate began to decrease in the second month for this cohort, except for the 60-69 age group where there was a 143% increase in mortality.

The need to address this problem is further highlighted by NCDs now making up a considerable proportion of healthcare attendances following natural disasters.[87,88] For example, in the five days following Severe Tropical Cyclone Yasi (2011) there was a 40% increase in daily emergency department presentations at The Townsville Hospital, Australia.[87] This was primarily due to exacerbations of NCDs and disrupted access to PHI for acute and chronic health care.[87] PHI priorities in the disaster setting include: communication; equipment; governance; physical structure; power; prevention; sanitation; service; supplies; surveillance;

transport; water; and workforce.[44] All vital for ensuring treatment, care and services for people with NCDs.[38,89,90]

Cyclones, floods and storms are the disasters that pose the greatest risk for people with NCDs in Australia (Table 1-2). The risk is greatest in the state of Queensland, which has recently experienced a number of large scale and devastating natural disasters including cyclones, damaging storms and far reaching floods.[73,91] For example, Severe Tropical Cyclone Larry (2006), flash flooding in the Lockyer Valley towns of Withcott, Grantham and Gatton (2011); Severe Tropical Cyclone Yasi (2011); flooding in Bundaberg (2013), Tropical Cyclone Nathan (2015) and Severe Tropical Cyclone Debbie (2017).[45]

Table 1-2 Australian disasters 1900-2016[92]

Disaster type	Events		Deaths		Affected		Damage	
	No.	%	No.	%	No.	%	000 US$	%
Earthquake	4	2%	12	1%	11,430	0%	$1,009,675	3%
Flood	96	46%	338	32%	3,845,263	85%	$15,230,172	40%
Storm	71	34%	212	20%	573,220	13%	$18,487,832	48%
Wildfire	37	18%	501	47%	90,931	2%	$3,494,394	9%

Please note: this excludes Cyclone Mahina, Queensland, in 1899 where over 400 people died

NCDs cause approximately 90% of all deaths in Queensland and account for 88% of the burden of disease and are responsible for 83% of recurrent health expenditure (these trends are similar across Australia).[27,34] The burden of NCDs, although lower at 78%, are also a concern for Indigenous people because they are attributed to 80% of the mortality gap when compared to non-Indigenous people (69.1 years for males, 10.6 years lower; 73.7 years for females, 9.5 years lower).[93,94] The situation is at its worst in rural and remote areas because as the distance from major cities and regional centres increases access to services decrease and disease risk factors rise along with the proportion of people with NCDs.[95]

There have been publications recognising the risk disasters pose for people with NCDs, however, the perspectives of people with NCDs have not been incorporated and mitigation strategies are not recommended. For example, WHO published *Noncommunicable diseases in*

emergencies, Emergency Management Australia *Disaster Health Handbook* and Australian Diabetes Educators Association (ADEA) *The needs of people with chronic diseases in natural disasters – A guide for state and local governments, emergency management services and the not-for-profit sector* but the recommendations provide little detail on what strategies disaster and health planners should implement to maximise the delivery of treatment and care before, during and after disasters.[96-99] This highlights the need to combine the perspectives of people with NCDs and disaster service providers to ensure feasible mitigation strategies can be developed and implemented.[100]

To further set the context for this research, the interaction with the social determinants of health and disaster management approaches at international, national and state levels are described in the following.

1.4.1 *Social determinants of health*

Many of the drivers that influence NCD exacerbation post disaster lie outside the direct responsibility of the health sector.[101] These include the conditions which people work, live, and age, and the wider set of forces that influence daily life such as economic policies, development agendas, social norms, social policies and political systems.[102] This notion is supported by the research direction being interrelated with the social determinants of health. More specifically, these include the factors of: education; individual lifestyle factors; living and working conditions; water and sanitation; and health care services (Figure 1-2).[103] The interactions between the social determinants of health and this research are discussed in the following.

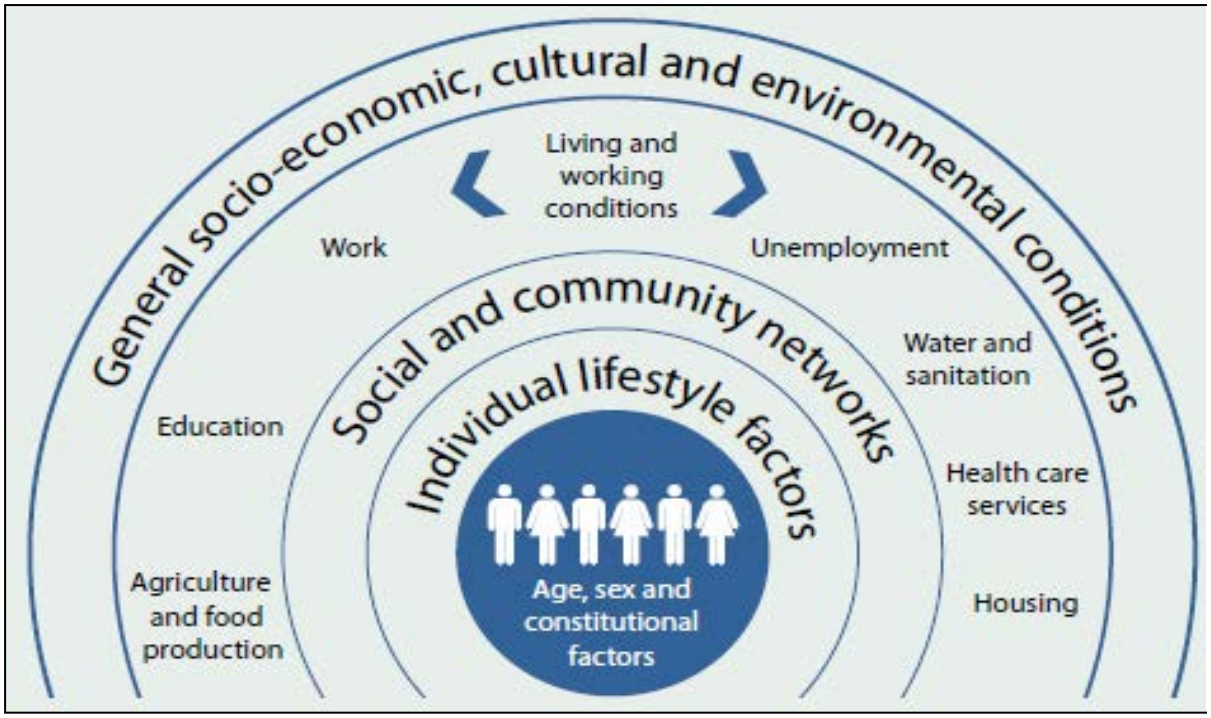

Figure 1-2 Social determinants of health[103]

1.4.1.1 Education

Educational attainment is associated with better health throughout life by allowing people to achieve stable employment, have a secure income, live in adequate housing, provide for families and cope with ill health by assisting them to make informed health care choices.[104] People with a lower level of education are associated with a higher risk of having a NCD and are more vulnerable to a disaster.[105-107]

1.4.1.2 Individual lifestyle factors

A persons health is influenced by their individual lifestyle factors.[104] These factors can be positive (vaccination) or negative (consuming alcohol at risky levels).[104] The prevalence of healthy lifestyle factors such as physical exercise and balanced diet tends to decrease among older persons and those on low incomes.[108] In addition, age is often a factor in determining ability to respond to a hazard and to recover from a disaster.

1.4.1.3 Living and working conditions

Living and working conditions have powerful effects on health equity and disaster risk.[109] In Australia the population living in 20% of areas with the greatest overall level of disadvantage (lowest socioeconomic areas) are 1.6 times as likely as the highest 20% to have at least two chronic health conditions, such as heart disease and diabetes.[104,110] People with poor living and working conditions are also less likely to have the structures, systems and economic cushion required to get through a long disaster response and recovery period.[111] In addition, those working in jobs associated with lower socioeconomic areas generally have workplaces at greater risk post disaster.[111]

1.4.1.4 Water and sanitation

Where there is limited access to safe water and effective sanitation there is an increased risk of illness.[112] Although the sanitary revolution launched in the 1850s provided the techniques required to control infectious disease, the risk continues particularly among low socioeconomic groups.[104,113] This risk has now been compounded by an increase in NCDs and exposure to hazardous substances such as asbestos in indoor and outdoor areas.[113] For people with NCDs, a disaster provides an increased risk because a breakdown in water and sanitation standards increases their risk of disease exacerbation or even death due to a reduction in treatment, care and services (for example, safe water for dialysis), increased exposure to harmful substances and a compromised immune system.[6,43]

1.4.1.5 Health care services

Access to, and effective utilisation of, health care is vital for good health and reducing disaster risk.[109] However, there is limited use of preventative health services among those with a low socioeconomic status, which is also the group at greatest risk of having a NCD.[114] This group is also more likely to receive short general practitioner consultations with longer assessments associated with a better quality of care.[115,116] People with a low socioeconomic status spend proportionally less on medical and health care than other households (3.0% and 5.1% of weekly expenditure, respectively, in 2009–10).[104,117] The risk posed to the health of people with NCDs is heightened further post disaster because there is generally a disruption to treatment, care and services, which increases the likelihood of exacerbation of existing conditions or event death.[43]

1.4.2 *Disaster management approaches and evolution*

The field of disaster management is still a relatively new area of knowledge and activity, which has undergone its own independent evolution.[118] For centuries, people considered disasters as unpredictable and inevitable events over which we have very little control.[119] In the modern era we have a greater understanding of many of the scientific causes of disaster hazards.[119] However, until the 1970s there was still a dominant view that the severity of a disaster was considered to be a function of the magnitude of the hazard.[120] The emphasis of researchers, national governments and the international community was searching for ways to improve responses to disasters and in the best of cases preparing for them.[121,122] Consequently, national emergency agencies were established or restructured in many countries during this period to institutionalise disaster management processes and practices.[118,122]

From the 1970s planners began to get involved and promote urban planning as an important mechanism for mitigating disasters, particularly in formally built areas.[118,120] Engineers and architects began to focus on ways to mitigate losses through physical and structural measures to reduce hazards (for example, through building levees and flood defences) or to increase the resistance of structures.[120] Meanwhile, researchers from the social sciences and humanities argued that the impact of a natural hazard depended not only on the physical resistance of a structure, but on the capacity of people to absorb the impact and recover from loss or damage.[120]

Since the 1970s, decision-making in disaster management has evolved from a top-down, "command and control" approach to the encouragement of "people-centred" approaches and local participation.[122] In the 1980s and 1990s, researchers in the social sciences and humanities triggered a shift in thinking by pointing out the impact of a natural hazard depends mainly on the vulnerability of the people affected.[118] Vulnerability reduction then began to be advanced as a key strategy for reducing disaster impact, though this proved elusive to implement.[120]

During the 1990s many pilot programs in the field of disaster management emerged in developing countries, which were prompted by the International Decade for Natural Disaster Reduction (IDNDR).[118] In 1994, governments came together as signatories to the Yokohama Strategy with the desire to address growing natural hazard vulnerability and increasing disaster losses.[122] A number of highly destructive largescale disasters occurred at the end of the 1990s and by this time it was clear that development processes were not only generating different

patterns of vulnerability, but were also altering and magnifying patterns of hazard.[120] As the IDNDR concluded, the international community was increasingly aware that natural disasters are a major threat to social and economic stability and that prevention was the main long-term solution to this threat.[123]

The United Nations International Strategy for Disaster Reduction (UNISDR) was established in 2000 as a successor to IDNDR.[120] The formation of UNISDR recognised that a reduction of disaster risk required a long-term engagement and an increased involvement from international organisations.[118] Ten years after the Yokohama Strategy was established, the devastating consequences of the Indian Ocean earthquake and tsunami renewed discussion about disaster risk reduction activities.[122] The World Conference on Disaster Reduction was held less than one month later and adopted the Hyogo Framework for Action (HFA) 2005–2015, which focused on building the resilience of Nations and communities to disasters.[122,123]

The goal of the HFA was to substantially reduce disaster losses by 2015 through building the resilience of nations and communities to disasters, which included reducing loss of lives and social, economic, and environmental assets when hazards strike.[124] Adoption of the framework was accompanied by the establishment of different tools and platforms designed to help implement disaster risk reduction (DRR) at regional, national, and local levels.[125] During the HFA there was acceleration in the formulation and implementation of policies and measures including: awareness-raising campaigns, risk assessments, early warning systems, emergency response capacities, legislation, and projects to address the increasing disaster risk threat to humanity.[126] Disasters around the world continued to produce human, economic, infrastructure, and ecological losses, especially in the most vulnerable and poorest nations during this period and therefore commitments to support DRR were renewed when HFA came to an end.[125]

On 18 March 2015, representatives from 187 UN Members States adopted the successor to the Hyogo Framework for Action and the first agreement of the post-2015 development agenda.[50] The Sendai Framework lays out an ambitious mandate, with science firmly at the core of the priorities for action and in the principle of "risk-informed decision-making".[127] Learning from the lessons of the HFA, the Sendai Framework prioritises understanding disaster risk and strengthening governance at global and regional levels and recognises this must involve application of risk information in all its dimensions.[127] Compared to the past when disaster agencies focused on safety regulations and recovery, agencies following this "people-centred"

approach now seek to transfer risk management responsibility from the government to the citizens, demanding precautionary actions that are appropriate for their unique situations.[122]

The Sendai Framework was the first of three separate global sustainable development processes aimed for long-term agreements.[128] The second was in September 2015 when the Sustainable Development Goals (SDG) were ratified followed by The Paris Agreement in December 2015, which focused on climate change mitigation efforts.[128,129] There is also a direct link with the SDG's goals 3.4 (NCDs) and 11.5 (disaster risk reduction).[130] This alignment of agreements redefined global priorities for reducing vulnerability and building resilience to present and future disasters as well as for overall poverty reduction for the next 15 years.[125]

1.4.2.1 United Nations disaster management system

Due to the presence of the United Nations (UN) in most countries across the world, it is well-placed to lead coordination of worldwide disaster management activities.[131] Recognising this and the need to contribute to increasing disaster and humanitarian crises, the General Assembly adopted resolution 2816 in 1971 to establish the Office of the United Nations Disaster Relief Coordinator (UNDRO).[130] UNDRO was created to mobilise, direct and coordinate activities of UN organisations and other bodies such as the International Red Cross and Red Crescent Movement in response to requests from countries requiring disaster relief assistance [132] During the 1980s as the UN found itself obliged to offer humanitarian assistance in situations of armed conflict as a lead agency and in other situations special ad hoc coordination bodies were established in the Horn of Africa (1984) and Afghanistan (1988).[132] However, this resulted in criticisms of UNDRO and growing concerns that ad hoc arrangements for humanitarian coordination were unsatisfactory.[132]

In 1991, the General Assembly adopted resolution 46/182 to strengthen the United Nations coordination of humanitarian assistance in complex emergencies and natural disasters.[133] This included: creating the Emergency Relief Coordinator (ERC) position to coordinate and facilitate humanitarian assistance; forming the Inter-Agency Standing Committee (IASC) to coordinate the assistance of UN and non-UN humanitarian partners; establishing the consolidated appeal system and the Central Emergency Revolving Fund to enhance response to time-critical funding requirements; and establishing the Department of Humanitarian Affairs (DHA).[132,133]

In 1998, as part of the Secretary-General's programme of reform, DHA was reorganised into the Office for the Coordination of Humanitarian Affairs (OCHA).[134] Its core functions include coordination of humanitarian response to complex emergencies and disasters through the IASC, which is chaired by the ERC.[132] The IASC ensures inter-agency decision-making in response to complex emergencies.[134] These responses include needs assessments, consolidated appeals, field coordination arrangements and the development of humanitarian policies.[133]

In 2005, humanitarian reforms were introduced to ensure more predictability, accountability and partnership in international humanitarian response through the establishment of the cluster system (Figure 1-3).[133] Clusters are groups of humanitarian organisations (UN and non-UN) working in the main sectors of humanitarian action (for example, shelter and health).[135] They are created when clear humanitarian needs exist within a sector, when there are numerous actors within sectors and when national authorities need coordination support.[135]

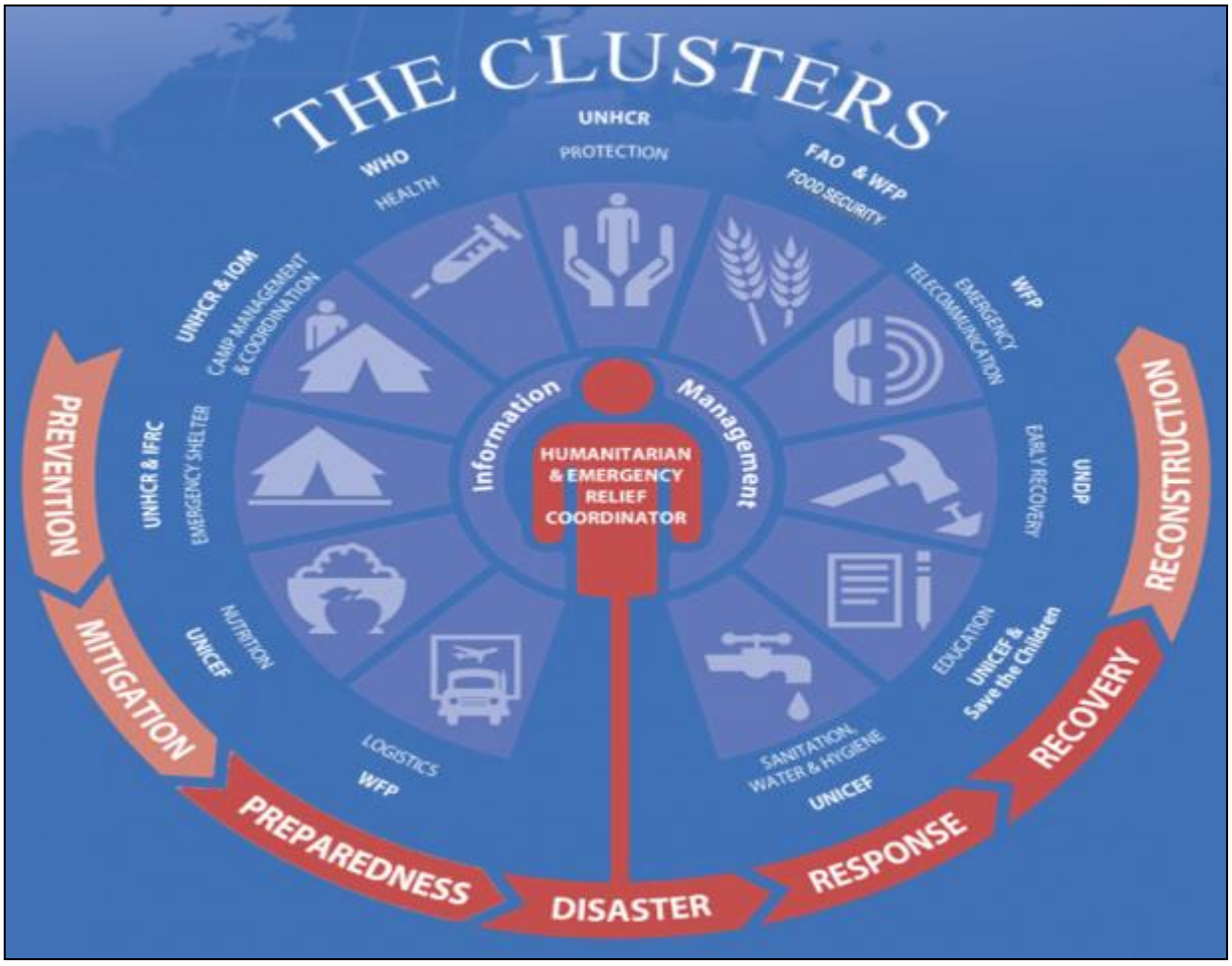

Figure 1-3 United Nations Clusters[135]

OCHA works closely with global cluster lead agencies and non-government organisations (NGO) to develop policies, coordinate inter-cluster issues, disseminate operational guidance and organise field support.[135] Under the Cluster Coordination system different UN bodies and/or NGOs take the lead depending on the cluster to be mobilised (for example, WHO leads the Health Cluster, United Nations Children's Fund (UNICEF) and Save the Children lead the Education Cluster).[127]

At the field level, OCHA helps ensure that the humanitarian system functions efficiently and in support of the Humanitarian Coordinator's leadership.[134] Clusters are established according to the needs of the situation; they may or may not correspond to the 11 global clusters (some may be combined, others not required).[136] OCHA provides guidance and support to the Humanitarian Coordinator (HC) and Humanitarian Country Team, facilitates inter-cluster coordination and helps to ensure coordination between clusters at all phases of the response, including needs assessments, joint planning and monitoring and evaluation.[135] Accountability is a key feature of the cluster approach with the HC retaining overall responsibility for ensuring the effectiveness of humanitarian response and is accountable to the ERC.[136]

1.4.2.2 Australian disaster management system

Australia has three tiers of government, each independently elected and answerable to the others only in broad terms defined by the constitution, relevant legislation, financial accountability or by political considerations.[3] Under the Australian Constitution, the state and territory (referred to as jurisdictions from this point) governments are primarily responsible for "the protection and preservation of civil life and property", in both peace and war (includes disaster management).[3,137] However, in the 1930s the worsening international situation led to a series of Premiers' Conferences which agreed on the need for coordination of Commonwealth and State activities in the area of civil defence (matters involving the protection of the civil population and services in time of war).[138]

Prior to this, the Australian approach was focused on response with the most visible disaster management agency in the early 1900s being the Australian Red Cross.[139] Fortunately, the wartime civil defence arrangements were not heavily put to the test and in 1945, Cabinet decided that post-war volunteer civil defence organisations in the states and territories should be retained.[138] Increasingly for the next twenty years these volunteer civil defence organisations

were being called on to assist during floods, windstorms, cyclones, building collapse and other civil emergencies.[138]

The seminal point in development of the Australian disaster management system was the 1967 Tasmanian bushfires where 62 people died and over 1300 homes and other properties were destroyed.[138,139] In recognition of the threat disasters posed to Australian communities the Natural Disaster Organisation (NDO) was formed within the Department of Defence.[121, 122] The primary role of the NDO was to co-ordinate national assistance to states and territories in the event of a natural disaster.[140] The Brisbane floods in January 1974 and then Cyclone Tracy in December 1974 cemented public resolve and political support for disaster planning.[141] Over 13,000 buildings were affected by the Brisbane floods and 14 people drowned in what was the worst city flooding in Australia's history.[140] Severe Tropical Cyclone Tracy (25 December 1974) was a disaster on a scale unparalleled in Australian history with 80% of Darwin's buildings destroyed or seriously damaged, 71 people died and approximately 35,000 people of the population of 45,000 evacuated, which was overseen by the NDO.[142,143]

The NDO continued for the next two decades until 1993 when it was renamed Emergency Management Australia (EMA) in order to broaden the range of emergencies to be addressed.[144,145] This also signalled an update to a more comprehensive "emergency risk management" approach to disasters and the integration of greater community awareness initiatives.[144] In response to the terrorist attacks on 11 September 2001 in New York and Washington DC, EMA was relocated from Defence to the Attorney-General's department to strengthen links to national security and counter terrorism. [144]

The Law, Crime and Community Safety Council (LCCSC) provides national leadership on emergency management and disaster resilience policy, which includes development of the *National Strategy for Disaster Resilience* (the Strategy).[12] LCCSC is responsible for overseeing implementation of the Strategy, which provides the foundation to shift the traditional emphasis of emergency management efforts from response and recovery from natural disasters to preparedness and prevention.[12] The Australia-New Zealand Emergency Management Committee (ANZEMC), includes senior officials from all jurisdictions, supports the LCCSC on emergency management matters by providing strategic leadership on emergency management policy and supporting related capability and capacity development activities including the Strategy.

The Australian Government lead for the Strategy and more broadly disaster and emergency management is EMA.[146] This is enhanced by an Australian Emergency Management Handbook Collection (the Collection) that links service delivery with the Strategy. The collection includes handbooks related to *Disaster Health* (published in 2011), *Community Recovery* (published in 2011) and *Australian Emergency Management Arrangements* (published in 2014). The Australian Institute for Disaster Resilience, which is supported by the Attorney-General's Department, assumed responsibility for publishing the collection in 2016 as part of its role in delivering emergency management education, training and professional development.[146,147]

The role of EMA in the disaster management system is to: support the states and territories develop their capacity for dealing with emergencies and disasters across all hazards; provide national coordination functions; assist states or territories when requested; and financial assistance in the form of cost sharing for response and recovery.[12,148] EMA maintains response plans for a range of physical assistance options that can be provided to state and territory governments and international partners responding to an emergency such as the *Australian Government Disaster Response Plan*, *National Catastrophic Natural Disaster Plan* and the *Australian Government Overseas Assistance Plan*. It is also the Australian Government focal point for the Sendai Framework and home to the Australian Government Crisis Coordination Centre (CCC).[146] The CCC is an all hazards facility that coordinates physical Australian Government assistance to states, territories and disasters overseas.[149]

1.4.2.3 Queensland disaster management system

The disaster management system in Queensland has evolved into its current form since World War II. Unlike other Australian states which set up new organisations for civil defence in response to World War II, arrangements were already in-place across Queensland with the police providing this service.[150] To formalise these arrangements the Queensland Parliament passed the *Air Raid Wardens Act 1939*, which was later replaced by the *Civil Defence Actions, 1939 to 1942*.[151] This legislation gave the Commissioner of Police power to appoint Wardens who could enter any place in the exercise of their duty.[150] A central Air Raid Precautions Committee headed by the secretary for Health and Home Affairs was also created in Brisbane and local committees formed, which were headed by Mayors, to develop civil defence plans for their location.[150,151]

In 1961 the Queensland Civil Defence Organisation was formed to deal with emergencies in the event of a nuclear war. It took no part in natural disaster operations until Cyclone Althea in December 1971 followed by a 1973 tornado in Brisbane and the 1974 Brisbane floods.[152] In 1975, the State Government introduced the *State Counter Disaster Organisation Act 1975*, which repealed the *Civil Defence Acts 1939 to 1942*.[153] The purpose was to establish two organisations, the State Counter Disaster Organisation (SCDO) and the State Emergency Service (SES).[154]

During 2002-03 the Department of Emergency Services undertook a comprehensive review of the *State Counter Disaster Organisation Act 1975*.[154] This was primarily in response to terrorist attacks in New York in 2001 and a Council of Australian Governments (COAG) report in 2002 that focused on the national disaster management system and arrangements.[155] The result was introduction of the *Disaster Management Act 2003* (the Act), which maintains many of the elements in the repealed *State Counter Disaster Organisation* Act 1975, while outlining requirements to focus on comprehensive disaster management, which include disaster mitigation, prevention, preparedness, response and recovery.[148,154,156,157] Recognising that disaster management requires this comprehensive approach, the Act was an update of the *State Counter Disaster Organisation Act 1975*, which was introduced after Brisbane's 1974 floods.[155]

The Act forms the legislative basis for the Queensland disaster management arrangements (QDMA) and provides a framework in which all levels of government, NGOs and stakeholders can work collaboratively in disaster management across the state.[156,157] Where necessary, the Act provides for the declaration of a disaster situation which activates powers that may be used by District Disaster Coordinator's (DDC) and declared disaster officers to assist with the management of an event.[156] Under the Act an Office of the Inspector-General of Emergency Management (Office of the IGEM) was been established to review and assess effectiveness of disaster management, establish standards and monitor compliance by departments with their disaster management responsibilities.[13,156]

The QDMA, which acknowledges the three levels of government identified in the Australian system, is based on a four tiered system to include an additional tier between local and state governments and known as disaster districts (Figure 1-4).[156,157] Disaster management policy and operations between Queensland and the Australian Government is coordinated through the

Crisis Coordination Centre (CCC).[148] Using this structure the QDMA is based on partnerships between government, NGOs, industry sectors and the local community.[157]

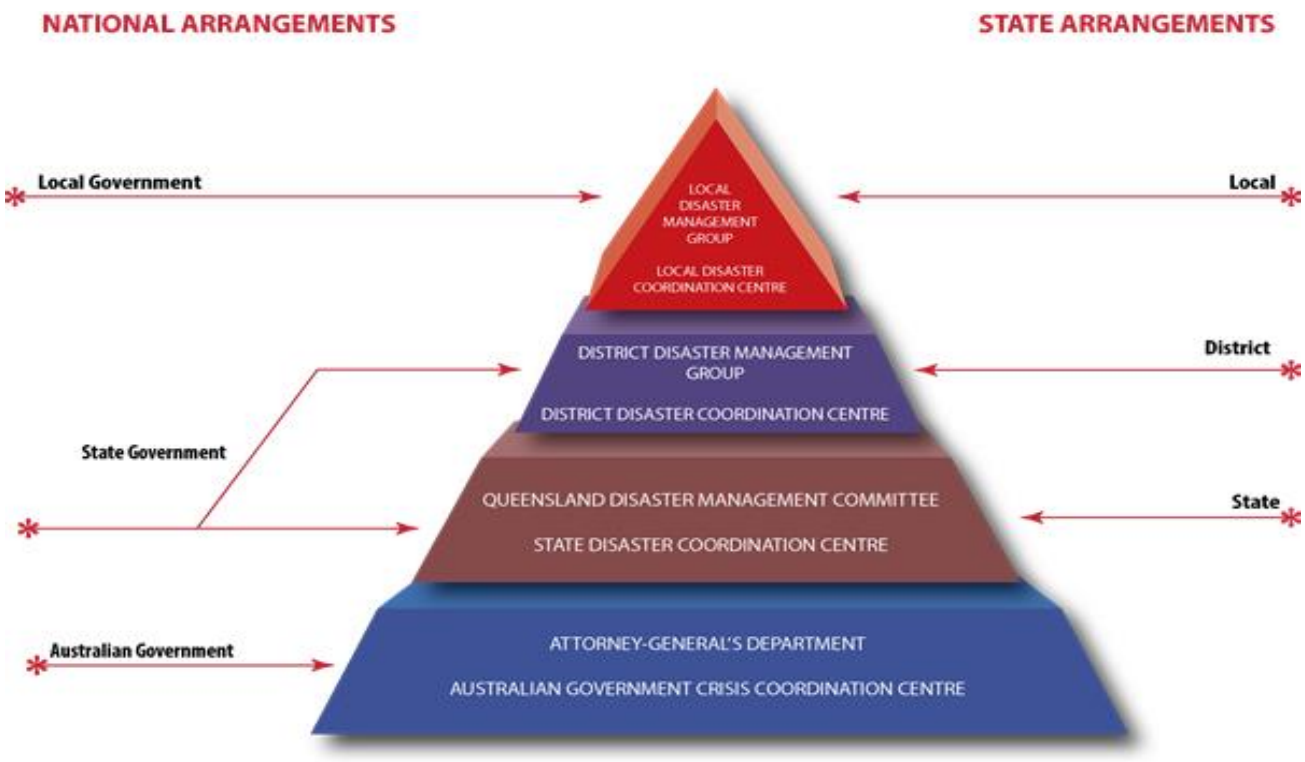

Figure 1-4 Queensland Disaster Management Arrangements[157]

There are a range of policies, guidelines and forms that complement the Act to enhance and govern disaster resilience in Queensland (www.disaster.qld.gov.au). The *Emergency Management Assurance Framework* (the Framework) underpins accountability for disaster managers by providing standards to ensure their legislative responsibilities are met and that programs are effective, aligned with good practice and meet the needs of Queensland communities.[152] The Framework establishes the *Standard for Disaster Management in Queensland*, which is created in-line with section 16N(1) of the Act and describes the attributes required for effective disaster management and forms the basis of assurance activities (for example, review of annual self-assessments and evaluation of disaster plans) undertaken by the Office of the IGEM.[152] This is complemented by the *State Disaster Management Plan*, disaster plans for each government department, Local Disaster Management Group (LDMG) and District Disaster Management Group (DDMG) plans.[157]

The governance arrangements in Queensland provide the framework required for risk based and comprehensive planning across the disaster management phases of prevention, preparedness, response and recovery (Figure 1-5).[148] This comprehensive approach ensures a balance between the reduction of risk and the enhancement of community resilience (for example, strengthening PHI to reduce the impact of disasters on people with NCDs), while ensuring effective response and recovery capabilities.[158] The four phases overlap and support each other, for example, recovery activities are likely to begin during the response phase and prevention/mitigation strategies considered during the recovery phase.[158] This approach and the associated functions are applicable across different types of disasters.

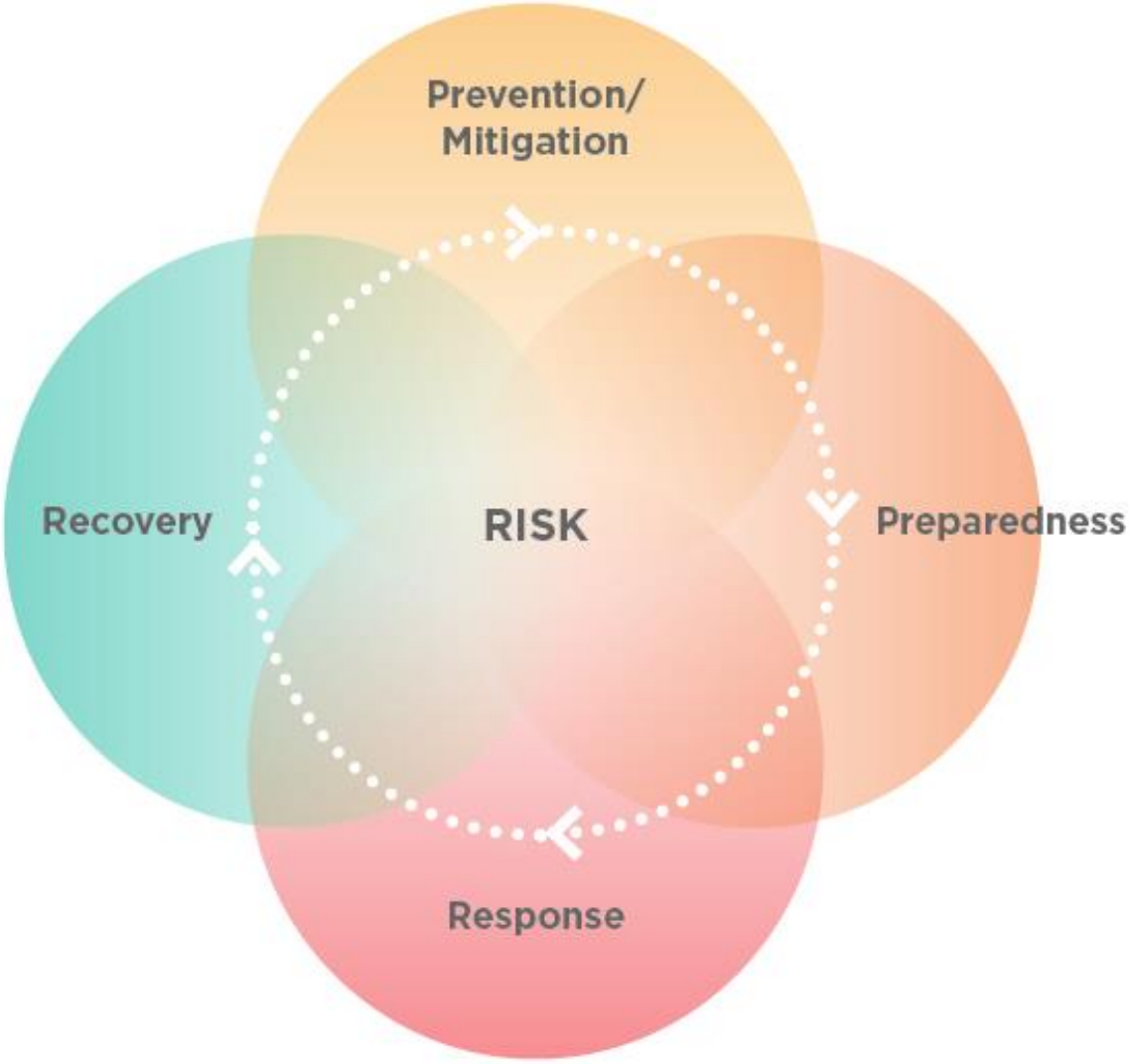

Figure 1-5 Comprehensive approach to disaster management[158]

There are several key management and coordination structures through which the functions of disaster management in Queensland are achieved.[157] These include:

- LDMG – Local governments are primarily responsible for managing disasters in their area due to their knowledge and understanding of social, environmental and economic issues. The LDMG is chaired by the local government (generally the Mayor) and membership comprises of local government, state emergency response agencies and any NGO or representative the chairperson appoints;

- DDMG – The group provides whole-of-government planning and coordination capacity to support local governments in disaster operations. The DDMG performs a "middle management" function within the QDMA by providing coordinated state government support when requested by local governments. The DDMG is chaired by the QPS and membership includes state agencies with hazard specific arrangements and functions in disaster management and local government representatives from each LDMG in the district; and

- Queensland Disaster Management Committee (QDMC) – Provides strategic direction and state-level decision making for disaster management and ensures prevention, preparedness, response and recovery activities are coordinated from a whole-of-government perspective. The Chair during the response phase is the Premier and the Deputy Premier during the prevention, preparedness and recovery phases. Membership includes primarily Ministers of agencies with hazard specific arrangements and functions in disaster management (including the Minister for Health). Director-General's and Chief Executive Officers of the same agencies are appointed as assisting officials. The Office of the IGEM is a Standing Observer. The Chair can invite other representatives to provide advice.[148,156,157]

Coordination centres are activated at the local, district and state level when the need arises to coordinate resources, information and provide support (for example, in preparation and/or response to a disaster). During disaster response operations the Queensland State Disaster Coordination Centre (SDCC) provides the interface with the Australian Government and other States and territories, coordinating requests for support to DDMGs and through them to LDMGs.[148] Two exceptions exist: Defence Assistance to the Civil Community (DACC) category one, where requests can be passed locally to an Australian Defence Force (ADF)

Local Commander; and hazard specific arrangements requiring direct communication between the state primary agency and their counterparts at the Australian Government level.[148]

1.4.2.4 Queensland Health Disaster Arrangements

Queensland Health is at the forefront of the Queensland Government's responsibilities for planning and managing public health emergencies, mass casualty incidents and disaster events.[159] The term "Queensland Health" refers to both the Department of Health and Hospital and Health Services (HHS), which is the functional lead agency for: public health and medical services; emergency medical retrieval; mass casualty and mass fatality management; heatwaves; pandemics; and biological (human related) and radiological incidents.[148] The Department of Health provides policy guidance and support for HHSs to fulfil the functional lead agency roles and if local resources are overwhelmed (for example, cyclone) will actively coordinate the health related prevention, preparedness, response and recovery activities.[160]

The Department of Health provides representation at the State disaster management level and HHSs the district and local levels.[159] This division of responsibilities reflects that health services in Queensland are delivered by 16 HHSs with the Department of Health providing overall management including monitoring performance across the state (Figure 1-6).[161] The geographic alignment of HHSs and DDMGs is close but not exact, with local agreements made where there is an overlap. The Department of Health activates the State Health Emergency Coordination Centre (SHECC) to support HHSs.

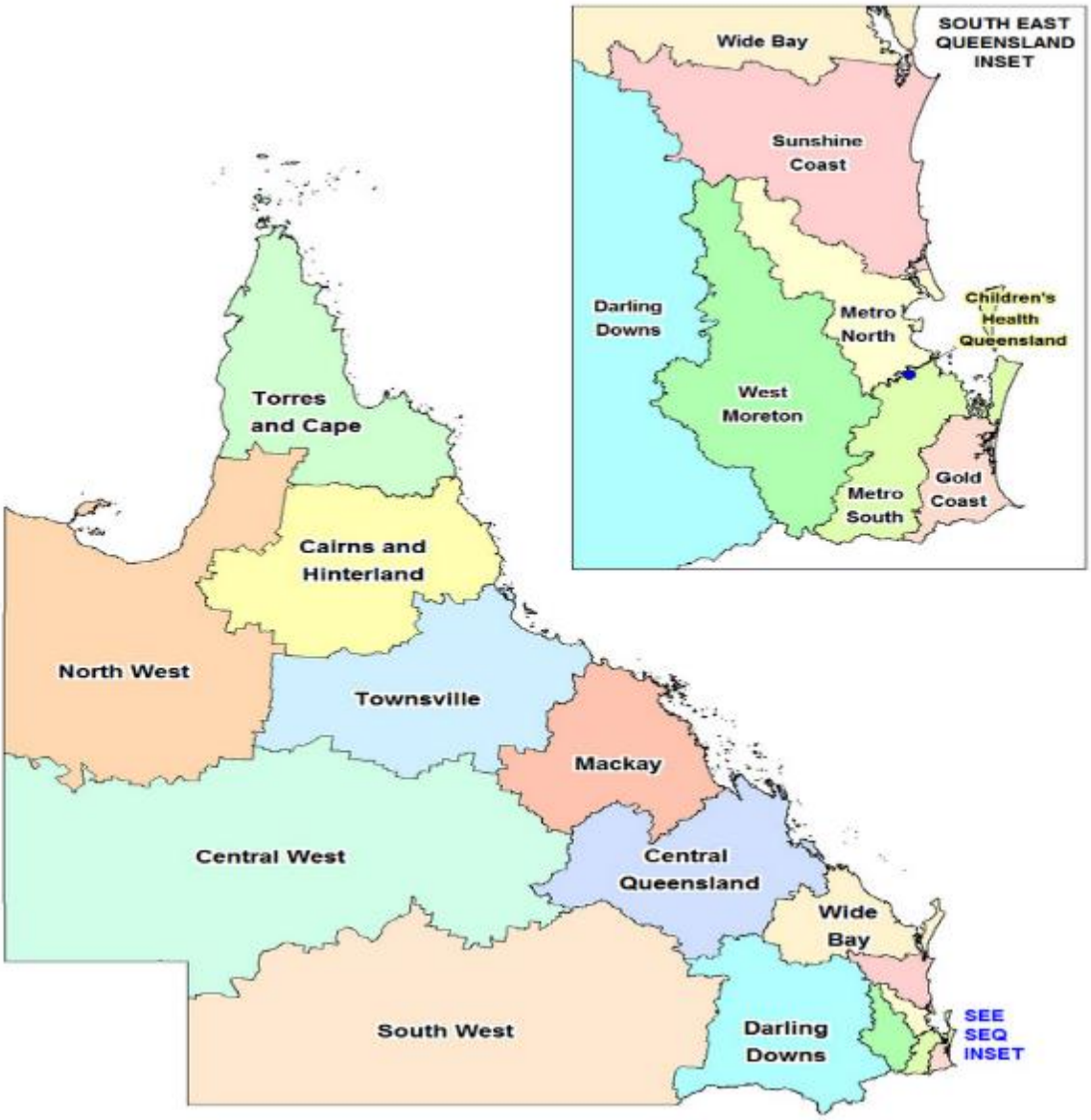

Figure 1-6 Map of Queensland Hospital and Health Services[161,162]

The HHSs are primarily responsible for leading and managing health related aspects of disasters and emergency incidents within its service area.[163] This includes all health facilities and services within the geographical area such as private, aged care, the primary health care sector and private providers, and membership to LDMG and DDMGs.[163] Incident management activities in hospitals and HHSs are coordinated through Health Emergency Operations Centres (HEOC) and requests for assistance due to a disaster are made to the SHECC. It is the HHS level where responsibility lies for treating people with NCDs and other community members before, during and after a disaster.[160]

1.5 Conclusion

This Chapter has discussed how the increasing frequency of natural disasters and NCD burden has created challenges for disaster and health systems. Natural disasters can damage PHI, which can result in acute exacerbation of NCDs, worsening prognosis and even death. The people at greatest risk are those with cancer, cardiovascular diseases, diabetes, respiratory conditions and renal diseases. Definitions for disasters, PHI and NCDs have also been provided along with a description of disaster management systems providing the foundation required to understand how and where the mitigation strategies developed can be situated for implementation. All of which provide the context for why this research is investigating the impact cyclone, flood and storm related disasters on PHI and the management of NCDs, and how this will be used to develop mitigation strategies for the risks identified. The methodology used to complete this research is discussed in the next chapter.

Chapter 1 References

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Chapter 2 Methodology

A sequential mixed methods exploratory approach (qualitative followed by quantitative) was used to complete the research in Queensland, Australia. This location was selected due to the risk of cyclone, flood and storm related disasters and burden of noncommunicable diseases (NCD). It was also the lead investigators state of residence and work at the time of the research. The qualitative component included: three literature reviews; and six focus groups and 42 interviews with a total of 105 participants. A thematic analysis was conducted to analyse qualitative data. This was followed by a modified Delphi process, which was conducted over three phases: questionnaire (n=14) to recommend mitigation strategies for the survey phase; workshop (n=18) to further explore questionnaire results (qualitative); and a survey (n=552) to rank and prioritise mitigation strategies. Descriptive statistics, bivariate and logistic regression modelling were used to analyse survey data. The participants were people with NCDs and disaster service providers. Participants for the questionnaire and workshop phases were disaster health experts. The data was sequentially analysed and triangulated to develop mitigation strategies.

This chapter describes in further detail the methodology used to investigate the impact of cyclone, flood and storm related disasters on public health infrastructure (PHI) and the management of NCDs, and develop strategies for mitigating the risks identified. This includes a description of the aim, objectives, theoretical paradigm, research strategies explored and methods of data collection.

2.1 Aim and Objectives

The aim was to investigate the impact of cyclone, flood and storm related disasters on PHI and the management of NCDs, and develop strategies for mitigating the risks identified.

2.1.1 *Research questions*

- ***What*** is the impact of cyclone, flood and storm related disasters on PHI and NCDs?
- ***How*** does a breakdown in PHI impact on the management of NCDs?
- ***How*** can this impact be potentially mitigated in the future?

2.1.2 *Objectives*

- To investigate the impact of cyclone, flood and storm related disasters on PHI and NCDs.
- Explore the links between NCDs and PHI, and how this can be impacted by cyclone, flood and storm related disasters.
- Identify modifiable risks that will reduce the impact of cyclone, flood and storm related disasters on the health and wellbeing of people with NCDs.
- Develop strategies for mitigating the risks identified.

2.2 Theoretical Paradigm

To determine the theoretic paradigm for the qualitative aspect of the research, a four phased process was followed based on Creswell (2013, pp. 16-18).[1] The first phase focused on exploring philosophical assumptions, which are the foundation for developing a study.[1] The second phase was to undertake researcher reflexivity, which included considering what the researcher brings to the study, such as personal history views of the world, which is vital to help inform the theoretical approach to the research.[1,2] The third phase explored various theoretical frameworks followed by the final phase, which identified the theoretical paradigm for the research.

Before the four phases are explored, it is important to understand the term theoretical paradigm. It is a set of basic beliefs or principles that represent a worldview that defines for its holder the nature of the "world", the individual's place in it and how reality is perceived.[1,3,4] This builds on Thomas Kuhn's (1962) first use of the term "paradigm" in his book titled *The Structure of Scientific Revolutions* where he used it to describe scientific concepts and practices for exploring problems and identifying solutions.[5] A paradigm provides a pattern, structure, framework or system for completing research in a specific field.[6] Within the theoretical paradigm there are four sets of philosophical assumptions: ontological; epistemological; axiological; and methodological.[1,7]

2.2.1 *Phase one – Philosophical Assumptions*

For the philosophical assumptions to be truly explored it was important to understand the term of "philosophy" and how it applied to this research. In Australia, the Macquarie Dictionary, describes philosophy as the study or science of the truths or principles underlying all knowledge, and the principles of a particular branch or subject of knowledge.[8] Philosophy can also be considered an attempt to resolve problems, typically of great practical importance or theoretical interest, which depend on the analysis of the basic concepts in the propositions in which they are stated.[9]

Creswell (2013, p.16), defines philosophy as "The use of abstract ideas and beliefs that inform research".[1] There has been a long history of debate about the philosophy definition. However, this research was not focused on exploring this in detail and for this reason the definition provided by Creswell (2013, p.16) will be used.[1] This definition was selected because the research process was based on his book titled *Qualitative Inquiry and Research Design*. In addition, the mandatory textbook for a qualitative research methods course completed as part of the PhD journey.

Within philosophy, Creswell (2013) describes four philosophical assumptions: ontological; epistemological; axiological; and methodological.[1] The research paradigm is an all-encompassing system of interrelated practice and thinking that define the nature of enquiry along these four philosophical assumptions.[10] The relationship between the assumptions is displayed in Figure 2-1 and described in the following.

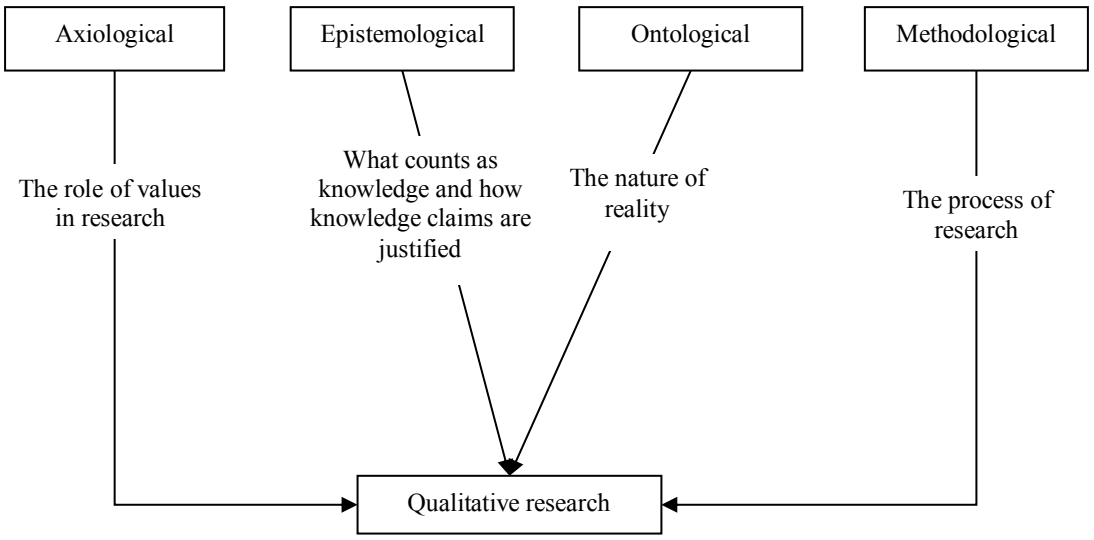

Figure 2-1 Philosophical Assumptions for Qualitative Research

2.2.1.1 Axiological

The axiological assumption refers to the researcher's beliefs about the meaning of ethics, values and moral behavior.[11] This includes the researcher actively reporting their values, embracing cultural norms when conducting the research, acknowledging the study is value-laden and that biases are present.[1,7,11] This was achieved throughout the research by: only progressing after receiving ethical approval and consent from participants; the researcher reflecting on his ethics and values with his primary supervisor prior to conducting focus groups, interviews and the modified Delphi process; and open discussions with participants about the researcher's history in preparing for and responding to disasters and how this shaped the research direction.

2.2.1.2 Epistemological

An epistemological assumption recognises that not all problems have a single right answer and that as research progresses some of what is considered true also changes and is synthesized into a new framework.[12] To achieve this in practice, the researcher attempts to lessen the distance to the participants, this includes an interaction and close dialogue.[1,13,14] For example, the researcher is immersed in the lives and culture of the people being studied.[14] This was achieved by: the researcher relying on quotes as evidence from the participants; being part of

the disaster management culture through employment, professional and research affiliations; and complementing this by interviewing people with NCDs.

2.2.1.3 Ontological

Ontological raises basic questions about the nature of reality and how we can best learn the truth about this reality.[14,15] This allows researchers to embrace the idea of multiple realities by exploring various forms of evidence from different individuals' perspectives and experiences.[1] The research achieved this by reporting different participant perspectives from focus groups, interviews and a modified Delphi process (questionnaire, workshop and survey). The data gathered informed development of the mitigation strategies.

2.2.1.4 Methodological

The methodological assumption relates to the need for an interactive link between the researcher and the participants in the definition and solution to the problem.[7] In this philosophy, the researcher interpretations are based on the participants experiences and actions.[16] This includes using inductive logic, studying the topic within its context and using an emerging design.[1] The research achieved this though the use of focus groups and interviews with participants to detail context of the problem and inform the questions for the modified Delphi process. This included the researcher following data pathways to inform development of the mitigation strategies.

2.2.2 *Phase two – Researcher Reflectivity*

The researcher's study and work in public health and disaster management at local, state, national levels in Australia and as a consultant internationally influenced the research direction. This included leading disaster management and public health workshops, training, lectures and activities across the Asia-Pacific, Europe and North America. He has also led responses to natural disasters and disease outbreaks (including Ebola and Dengue), public health projects in Indigenous communities, facilitated delivery of health services to asylum seekers and worked at executive levels in government.

The development of the initial research questions and direction was based on the researcher's experience, studies and discussions with health professionals, disaster officers and other people affected by disasters. The focus on PHI was based on his field experience responding to Severe

Tropical Cyclone's Larry (2006) and Yasi (2011) and witnessing the impact water treatment, sewage systems, pharmaceutical supplies, food supply, resources and more broadly the community. He also lived in the area subject to the research (Cairns, Queensland, Australia).

The research interests demonstrated a commitment by the researcher to expand the focus of public health professionals in the disaster setting. On the surface, responses to recent disasters appeared to be satisfactory, however, Queensland and Australia have not been truly tested by a Severe Tropical Cyclone striking a densely populated area. For this reason, the researcher determined it was vital for research to be undertaken to ensure the community, decision-makers, health professionals and disaster management systems were aware of the risks for people with NCDs and plan accordingly.

2.2.3 *Phase three – Theoretical frameworks*

To determine the theoretical paradigm for the research, various epistemological positions were explored. Epistemology is a branch of philosophy concerned with the theory of knowledge.[17] This involves thinking about the nature of knowledge itself, its scope, and the validity and reliability of claims to knowledge.[17] The epistemological position informs the research methodology (strategy) and methods of collection and analysis (techniques or procedures used to answer the questions).[1,18] To identify the theoretical perspective, a range of philosophies were explored, including constructivism, positivism, pragmatism and transformative/postmodernism.[1] Each is described in the following.

2.2.3.1 Constructivism

The constructivism philosophy is based on generating or inductively developing a theory or pattern of meaning.[1] This perspective recognises a research problem informs the initial methodological choices for data collected and that the researcher is part of the study.[19] In this paradigm, a literary style of writing is used along with an inductive method of emerging ideas (through consensus) obtained through interviews, observing and analysis of texts.[1]

This philosophy is relevant to the research because the problem, disasters and high burden of NCDs, informed the initial methodological choices for data collected. It reflects my approach to life, profession, education and residence/work in the study location during the research. In addition, it allows the research to rely on quotes as evidence and close collaboration with

participants, which related to my role within the Queensland disaster system as a health representative on the Cairns Local Disaster Management Group (LDMG) and Far North District Disaster Management Group (DDMG) and experience/training in public health.

2.2.3.2 Positivism

This is a philosophy of science that is constructed through research and statistics.[1] Positivism suggests there is a straightforward relationship between the world (objects, events, phenomena) and our perception, and understanding, of it.[17] According to Guba (1990, p. 22) positivism asserts that objective accounts of the world can be given as, "…*there is a reality out there to be studied, captured, and understood*…".[2] Scientific knowledge is based on facts and values that can be obtained by observation, experiment and repetition.[10,20] The truth is found by following general rules of method, largely independent of the content and context of the investigation.[6] In this paradigm, the objective of the research is to create new knowledge and deductive methods are important to test theories, specify variables and make comparisons among groups.[1] There were elements of this philosophy in the research (use of statistical analysis techniques), however, this was not reflected throughout the study because the relationship between disasters and the impact on people with NCDs was not straightforward.

2.2.3.3 Pragmatism

This is a philosophy that focuses on the idea that the meaning of concepts can be found in their practical use, thought guides action and the test for truth is the practical consequences of beliefs.[6] According to Shaw, Connelly & Zecevic (2010, p. 514) "the primary focus on practicality and real problems, rejecting many of the rigid criteria for knowledge claims posed by other paradigms".[21] Reality is known through using many tools of research that reflect both deductive (objective) evidence and inductive (subjective) evidence.[1] Researchers believe paradigms can remain separate but can also be mixed into another research paradigm.[22] The research process involves both quantitative and qualitative approaches to data collection and analysis.[1] There were aspects of this philosophy in the research (use of quantitative and qualitative techniques), however, this was not reflected throughout the study as there was not a focus on practical use of the mitigation strategies. The study was focused on a theoretical outcome.

2.2.3.4 Transformative/Postmodernisation

The philosophy is based on co-created findings with multiple ways of knowing.[1] This paradigm engages an on-going conflict with the powers of oppression and criticises modernism and its concept of facts and science.[6,23] The aim is to openly critique the status quo, focus on the conflicts and constraints in contemporary society, and seek to bring about cultural, political and social change that would eliminate the causes of alienation and domination.[23] Researchers use collaborative processes of research, political participation is encouraged, there is a questioning of methods, issues and concerns are highlighted.[1] There were elements of this philosophy in the research, which included challenging the status quo of disaster management systems to expand focus beyond immediate trauma and communicable disease to include NCDs. However, political participation was not encouraged and there was no focus on overcoming oppression or criticising modernism.

2.2.4 *Phase four – Theoretical paradigm*

Of the theoretical perspectives explored, the constructivism philosophy underpins this research. There are aspects of pragmatism within this study but there are little to no aspects of positivism and transformative/postmodernisation reflected. This constructivism perspective recognises that a research problem (disaster risk and high-burden of NCDs) informed the initial methodological choices for data collected and the researcher is part of the study (the researcher's studies, research and experience in public health and disaster management).[19]

Aspects of pragmatism are reflected in the study but this is not the theoretical perspective. Different methods (literature reviews, focus groups, interviews and a modified Delphi process) were sequentially used to develop results that are meaningful and practical. The reality of the problem was co-constructed between the researcher and participants due to the scant research in this field. Also, the research focused on inductive evidence (where data is used to generate ideas) with little to no focus on deductive processes (where research confirms or negates an idea).[24] The research resulted in the development of mitigation strategies that will need to be tested following a pragmatism philosophy.

Constructivism also reflects the researchers approach to life, profession, research and education. Using a problem to inform the initial methodological choices to collect data, and understanding the researcher, was part of the study is the preferred approach to solving

problems. Demonstrated by the researchers professional and research orientated publications into the public health aspects of disasters.[25-32] Another appealing factor of this approach is that it allowed the research to rely on quotes as evidence and close collaboration with participants to develop the mitigation strategies.

2.3 Research Strategies

There are five qualitative approaches used to inform a research strategy: narrative; phenomenology; grounded theory; ethnography; and case study.[1] To select the research strategy these approaches have been analysed in the following along with justification for the selected approach, which was narrative. This process was vital to formulate the context, problem and identify how information would be sought to answer the research aim and objectives.[1,33]

2.3.1 *Case study*

The case study approach employs in-depth investigation of any social phenomenon, using various sources of data.[34] A feature is that different methods are combined with the purpose of examining the case from different angles, to triangulate by combining methodologies.[35] The researcher collects and analyses many forms of qualitative data including interviews, observations, documents and/or audio-visual materials.[1] The analysis generally involves a description of the case, categorising themes, tabulating the frequency of events, ordering the information and uncovering information found during the study.[1,36] The case study often concludes with a chronological report and/or by addressing the proposition (research question).[37] The aim is to describe the patterns and explanations required to help the reader understand the implications of the findings.[36] A case study approach was applied in some degree for the literature review that focused on Severe Tropical Cyclone Yasi and compared this with other similar disaster types across the world, however, this was not the overall research strategy.[26]

2.3.2 *Ethnography*

Ethnography focuses on developing a complex and complete description of the culture, practices and beliefs of a group from a participants perspective.[1,34,38] There is a strong emphasis

on exploring the nature of a particular social phenomenon, rather than testing a hypothesis.[6] To facilitate an in-depth study there is an investigation of a small number of cases.[39] Typically there is not much known about how the group functions and the reader develops a new and novel understanding.[1] Researchers work primarily with unstructured data, which has not been coded at the point of collection in terms of a closed set of analytic categories.[39] The research produces verbal descriptions, explanations and theories.[6,39] The research did not apply this strategy because the problem investigated was not focused on a specific culture, practice or belief. Also, rather than focusing on a small number of cases, the point of saturation was the goal for the qualitative component and maximising participation for quantitative aspects.

2.3.3 *Grounded Theory*

Grounded theory is a form of qualitative research used for constructing a theory that is grounded in data.[40] The researcher is required to come into the study with an open mind.[41] A set of procedures are used to develop an inductively derived theory that is faithful to the evidence.[38] The research begins with the researcher generating a general explanation (a theory) of a process, action, or interaction that can be shaped by a literature review and/or the views of a large number of participants.[42] Theoretical sampling (a form of purposive sampling) is often used to select participants based on their potential contribution to the theory.[43] The primary form of data collection is interviewing and the researcher is constantly comparing the data gathered to understand the emerging theory.[1] The theory is often presented as a diagram, hypotheses or as a discussion.[1,44] The research approach was not aligned with grounded theory because there was some data, although limited, prior to the study about the impact of disasters on the treatment, care and services for people with NCDs.

2.3.4 *Narrative*

Narrative research is a story told by a sequence of words, actions or images.[6] Narrative researchers usually embrace the assumption that the story is one if not the fundamental unit that accounts for an individual's experience.[45] As a method, it begins with the experiences as expressed in lived and told stories of individuals.[1] Researchers may use survey/measurement strategies to calculate the impact of narratives or use coding followed by translating the codes to numbers and then using statistical analysis.[45] Narrative stories are often shaped by the

researchers into a chronology of events and use the analytic procedures to produce explanatory stories.[46]

This research was aligned with the narrative approach. The research commenced with literature reviews followed by exploring the experiences of people through interviews and focus groups. Thematic analysis techniques (including coding) were used to analyse qualitative data. The results from this phase where then surveyed, measured and analysed using statistical analysis techniques through a modified Delphi process. The research and results were analysed in a chorological order and used to describe how disasters impact on treatment, care and services for people with NCDs, describe the consequences and present mitigation strategies.

2.3.5 *Phenomenology*

A phenomenological study describes the common meaning for several individuals of their lived experiences of a concept or phenomenon.[1] Phenomenology's first step is to avoid all misconstructions and impositions placed on experience in advance, whether these are drawn from religious or cultural traditions, from everyday common sense, or, indeed, from science itself.[47] Phenomenology aims to be systematic, methodical, general, and critical.[48] As a method it typically involves interviewing individuals who have experienced the phenomenon, however, this can be expanded to include poems, observations and documents.[1,47] The analysis encompasses three interlocking steps: phenomenological reduction (suspending judgment until analysis is complete); description; and search for essences.[48] The research concludes with a descriptive passage that incorporates what individuals have experienced and how it was experienced (the essence).[1] The research was not aligned with this approach because the focus was beyond several individuals and the interviewing of participants. Also, there were no observations of behaviour or focus on exploring documents beyond the literature reviews and defining the essence of the problem.

2.3.6 *Research Strategy*

A combination of constructivism and the narrative approach best describes the research strategy. The constructivism element refers to how the problem, disasters and high burden of NCDs, informed the initial methodological choices for data collected and the researcher is part of the study.[19] This reflects the inductive method use to allow the emergence of ideas (for

example, mitigation strategies).[1] The narrative aspect refers to how after the literature reviews the research began with interviews and focus groups to explore the experiences of individuals.[1] This followed by a modified Delphi process, which refined the findings and mitigation strategies. Also, throughout the research various survey/measurement strategies were chronologically applied.[45]

Application of this research strategy allowed the researcher to focus on a process that had distinct sequential steps occurring over time.[1] These included: literature reviews; focus groups; interviews; and surveys followed by a modified Delphi process (questionnaire, workshop and survey). The research and results were conducted chronologically then integrated to develop mitigation strategies.

2.4 Methods of Collection and Analysis

A sequential mixed methods approach was used to collect and analyse the data (Figure 2-2).[49] More specifically, a sequential exploratory design was used where qualitative data was collected and analysed followed by quantitative analysis.[50] Qualitative refers to collecting data in the form of words and quantitative occurs using numbers.[38] This difference in data collection techniques allowed the mixed methods sequential explorative study approach (qualitative followed by quantitative) to effectively explore relationships, refine and test emerging ideas, develop new strategies and generalise the mitigation strategies (findings).[50]

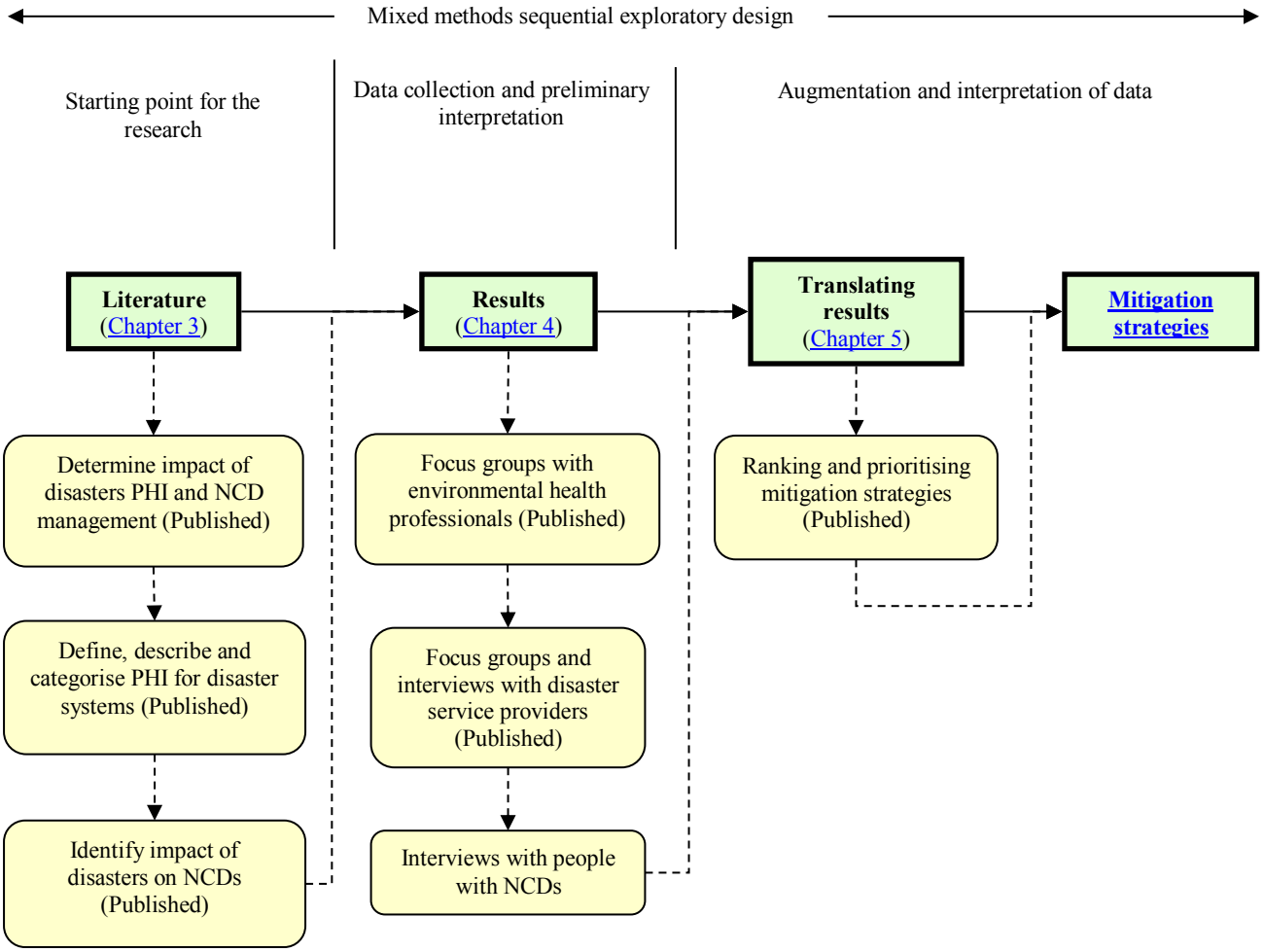

Figure 2-2 Research methods

The study process helped to validate the research findings while allowing for a fuller picture and deeper understanding of the phenomenon investigated (disasters and their impact on PHI and the management of NCDs).[51] It also provided a more comprehensive analysis of factors than either method alone.[52] By using this approach, this study was able to effectively investigate the impact of disasters on PHI and the management of NCDs, explore links between NCDs and PHI, identify modifiable risks and develop mitigation strategies that were ready for implementation.

The participants, study location, recruitment, data collection and analysis process, including literature reviews, focus groups and interviews, and modified Delphi process (questionnaire, workshop and survey) are described in the following along with the ethical considerations.

2.4.1 *Participants*

A purposeful sampling strategy was used to select participants. The participants for the focus groups and interviews were people with NCDs, disasters service providers and environmental health professionals. The modified Delphi process (questionnaire, workshop and survey) included an additional group, disaster health experts, who were used to rank and prioritise mitigation strategies for inclusion in the survey. These groups are of central importance for informing the research, thus the term purposeful sampling, and are described in the following.[53]

2.4.1.1 People with NCDs

A combination of the people with the most common NCDs in Queensland and those at greatest risk post disaster were the research focus. This included (but was not limited to) people with cancer, cardiovascular disease, chronic respiratory disease, diabetes and renal diseases.[27,54] These conditions are also long-lasting and place great burden on patients, health services and fiscal systems.[55,56] This group was vital for the research as it is their experience and expectations of PHI during and immediately after a disaster that influenced the research outcome.

2.4.1.2 Disaster Service Providers

The experiences of three types of disaster service providers were explored: responders, coordinators and government officials. These groups were invited to participate because their perceptions, experience and knowledge is vital in influencing strategies for reducing disaster exacerbated NCDs through PHI resilience. A description is provided below:

- *Responder*: This group included doctors (for example, medical officer and physician), nurses, paramedics, police officers and representatives from non-government organisations (NGO) such as the Australian Diabetes Educators Association, Australian Red Cross and the Kidney Support Network. This group is involved in the preparedness, prevention, response and recovery arrangements and

includes various individuals, organisations and leading local players in disaster health management.[57]

- *Coordinator*: This group included local disaster coordinators, members of local, district disaster management groups, and disaster management officers from Queensland Fire and Emergency Services. This group is a conduit between Local and State Disaster Management Group's groups and has specialist knowledge of the principles of disaster management.[57]

- *Government officials*: This group includes representatives from the Department of Health (Queensland), Queensland Police Service, Queensland Fire and Emergency Services and Queensland Ambulance Service who had a state-wide disaster management role. This group was based in the capital of Queensland, Australia (Brisbane). Overall this group is responsible for leading, designing and managing the state-wide preparation, prevention, response and recovery phases of disaster management.[57]

2.4.1.3 Environmental Health Professionals

Environmental health professionals are often employed at local and state government levels in communities where disasters occur and the core elements of their work are indirectly linked to maintaining treatment, care and services for people with NCDs.[31] In a disaster situation, particularly in Queensland, Australia, this includes working across and with disciplines to address risks relating to: drinking water; hazardous substances; general waste; sanitation; food safety; communicable diseases; vector issues; and mass gatherings.[25,58] These activities can be considered vital for maintaining the health and wellbeing of people with NCDs before, during and after a disaster.[25,29,59]

2.4.1.4 Disaster Health Expert Group (modified Delphi process)

The group included disaster health managers and directors from Queensland Health. This group often represents Queensland Health on LDMG's, DDMG's and State Disaster Management Committee, and would be responsible for leading implementation of the mitigation strategies.[58]

2.4.2 *Study location*

The initial target locations for the research were the geographical areas covered by the Cairns and Hinterland Hospital and Health Service (HHS), Darling Downs HHS and Townsville HHS. Representatives from central government and non-government agencies in Brisbane (State Capital), Queensland, Australia, with disaster management responsibilities were invited to participate. These locations were used for the focus groups and interviews, however, due to the differences in the study methodology for the modified Delphi process (questionnaire, workshop and survey) the location for this phase was expanded to across Queensland. The study location is described in more detail in the following.

2.4.2.1 Focus groups and interviews

The focus groups and interviews included the geographical areas of the Cairns and Hinterland HHS, Darling Downs HHS and Townsville HHS. Representatives from central government and non-government agencies in Brisbane (state capital), Queensland, Australia, with disaster management responsibilities were invited to participate. These locations were the focus due to their high NCD burden and recent disasters such as Severe Tropical Cyclone Larry (2006), flash flooding in the Lockyer Valley (2011); Severe Tropical Cyclone Yasi (2011); Tropical Cyclone Nathan (2015) and Severe Tropical Cyclone Debbie (2017). [28,56,60] Recall bias was a potential issue, however, both the experience and expectations of PHI during and immediately after a cyclone, flood and storm related disaster provided rich information. Disaster specialists and government officials in Brisbane were invited to participate as their decisions influence PHI, management of NCDs and disaster responses.

2.4.2.2 Modified Delphi process (questionnaire, workshop and survey)

The same geographical areas were initially targeted as the focus groups and interviews, however, the modified Delphi process included an online survey and therefore it was not possible to limit participation to these areas. Also, to ensure an adequate number of participants for the questionnaire and workshop phase (disaster health expert group), the geographical area was expanded to across Queensland. The survey was distributed through government departments and professional organisations across Queensland, Australia. The majority of these organisations were unable to limit distribution by region. This resulted in participants

from additional locations across Queensland, which was viewed as a positive because it increased the number of people who participated in the research.

2.4.3 *Recruitment*

A purposive sampling strategy was used to recruit participants. Participants were recruited through professional networks, support organisations and the public domain. This included letters, e-mail, discussion with participants from focus groups and interviews. Appropriate organisational representatives were also contacted (for example, health professionals and NCD support organisations) and public advertising used such as notice boards at health care facilities. This aim was to maximise the number of participants.

The organisations invited to participate and support the research were the Department of Health; Queensland Ambulance Service; Queensland Fire and Emergency Service; and Queensland Police Service. This was complemented by NGOs and NCD support organisations such as:

- Asthma Australia
- Australian Diabetes Educators Association
- Australian Medical Association
- Australian Red Cross
- Cancer Council Queensland
- Diabetes Queensland
- Environmental Health Australia
- Health Consumer Queensland
- Kidney Health Australia
- Kidney Support Network
- Life without borders
- Lung Foundation Australia
- Primary Health Network
- Public Health Association of Australia
- Royal Australian College of General Practitioners
- The Heart Foundation

2.4.4 *Data Collection and Analysis*

The data collection and analysis occurred over three phases. The first phase included three literature reviews, which acted as a starting point for the research by helping formulate the research questions. Phase two included focus groups and interviews with people who had a NCD and disaster service providers. Phase three was a modified Delphi process which included a questionnaire, workshop and survey. The questionnaire and workshop were conducted sequentially with a disaster health expert group to rank, prioritise and augment the themes from the focus groups and interviews for a survey. The survey was then distributed and completed by disaster service providers and people with NCDs to rank and prioritise PHI concerns and mitigation strategies for maintaining treatment, care and services during and after a disaster. This information was integrated to develop the mitigation strategies. An overview of the three phases is provided in the following.

2.4.4.1 Phase one – Literature reviews

Three literature reviews were completed and published. The first focused on determining if cyclone related disasters can impact on PHI and the management of NCDs.[26] The second focused on defining and describing PHI for the disaster setting.[30] The third and final paper identified the impact of disasters on NCD treatment, care and services.[27] All three papers were interrelated and were vital for informing phase two, focus group and interviews that investigated the impact of cyclone, flood and storm related disasters on PHI and NCDs, and identified mitigation strategies. An overview of each literature review is provided in the following.

> *Literature review 1 – Impact of cyclone related disasters on public health infrastructure and noncommunicable disease management*
>
> *Publication – Ryan B, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2015). Analyzing the impact of Severe Tropical Cyclone Yasi on public health infrastructure and the management of non-communicable diseases. Prehospital and Disaster Medicine. 30(1):1-10. Impact factor 1.03 (ResearchGate 2015); Indexing ESCI, National Library of Medicine, Scopus, OCLC, Ovid, Pan American Health Organization, ProQuest, Safe Publications, Thomson Reuters and U.S. National Library of Medicine; Google Scholar citations 14.*

This literature review was the starting point for the research and is available in Chapter 3 and Appendix A. The aim was to collect and analyse data (literature) on the impact of Australia's Severe Tropical Cyclone Yasi (2011), on PHI and the management of NCDs. The findings were compared with data from other cyclone events around the world.

A two-phased process was used to complete the literature review with the first focused on Severe Tropical Cyclone Yasi and the second on other similar events around the world. An overview of the databases searched, search terms and inclusion/criteria for each is described in the following:

- Phase one: CINAHL, Google Scholar, Google and Medline databases were searched in May 2013. The date range was 26 January 2011 to 2 May 2013. Initially the search combined the terms "cyclone Yasi", "public health infrastructure" and "noncommunicable diseases". This search found no relevant articles. The search was then expanded to include the most common NCDs in Queensland, Australia, (cancer, cardiovascular disease, chronic respiratory diseases, diabetes and renal diseases) and the term "chronic disease".[61] Searches were conducted without the phrase "public health infrastructure". An article was considered valid if the inclusion criteria were achieved, which included: literature meeting the search terms; events a week prior Severe Tropical Cyclone Yasi and four weeks after. Abstracts that did not include Severe Tropical Cyclone Yasi and NCDs were excluded.

- Phase two: To ensure consistency with phase one, a database search was also conducted using the CINAHL, Google Scholar, Google and Medline databases. The search occurred on 5 July 2013 and included the terms "cyclone", "hurricane" or "typhoon" and NCDs subject to the research in phase one (cancer, cardiovascular disease, chronic respiratory disease, diabetes and renal diseases), with no time limits applied to the search. A search was also undertaken using the term "chronic disease" to maximise literature identified. Initially the term "public health infrastructure" was omitted to provide consistency with the method used for Severe Tropical Cyclone Yasi. This strategy was effective in all databases, however, a test search

for cancer in Medline resulted in 1,600 articles. Therefore, the term "public health infrastructure" was applied to the search in the Medline database.

An article was considered valid if the inclusion criteria were achieved. This included: literature (abstracts) meeting the search terms; events the week prior to a cyclone and the four weeks after;[62] and literature referring to Severe Tropical Cyclone Yasi was excluded as they were already searched. No other geographical, time or language limits were applied. Reference lists were also reviewed to identify relevant literature. The selected literature was then analysed and compared with the themes from phase one.

This two-phased process allowed a comparison between a disaster, which resulted in Australia's largest hospital evacuation (Cairns Hospital), and other weather events across the world. The research provided an understanding of areas for improvement, specifically enhancing protective PHI and the development of strategies for maintaining treatment and alternative care options. This information was vital for informing the research direction.

Literature review 2 – Defining, describing and categorizing public health infrastructure for disasters

Publication – Ryan B, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2016). Defining, describing and categorizing public health infrastructure for cyclone, flood and storm related disasters. Disaster Medicine and Public Health Preparedness. Vol 1:1-13. Impact factor 1.354 (Thomson Reuters 2017); Indexing Adis International Ltd., CABI, EBSCOhost, Elsevier BV, National Library of Medicine, Thomson Reuters and U.S. National Library of Medicine; Google Scholar citations 7.

This literature review was the final process before commencing the focus groups and interviews and is available in Chapter 3 and Appendix B. The aim was to analyse the available databases to define, describe and categorise PHI priorities for tropical cyclone, flood, storm, tornado and tsunami related disasters. This was completed using an integrated literature review methodology.

The search terms were: "public health infrastructure", "public health" or "infrastructure"; and "define", "describe" and "categorise"; and "flood", "cyclone", "storm", "hurricane", "tornado", "tsunami" or "typhoon"; and "disaster".

Databases searched were CINAHL, Medline, PsycINFO, Science Direct, Scopus and Wiley Online. These databases were selected to maximise the literature searched and minimise the risk of missing relevant articles. An all field search was conducted between March and May 2014 by using the search terms with a date limit of 31 December 2013.

Because this was a novel area of research, additional exclusions were required for some databases. The Medline search was limited to articles with abstracts and references, pharmacological actions, humans and core clinical journals. The CIHNAL, Scopus and Science Direct searches were limited to: Medicine; Nursing; Health Professions; Pharmacology, Toxicology and Pharmaceutics; Dentistry and Engineering. This approach ensured the search was tailored to each database, which increased the efficiency and accuracy.

The data collected was thematically analysed and then the degree of interdependency (or interdependency index) calculated.[63] The thematic analysis included a grouping of PHI themes identified and a description of key phrases, ideas and concepts for each theme. The degree of interdependency was then calculated to prioritise PHI based on its importance for maintaining health services for the community. This was evaluated by values between 0 and 1 were used, where 0 represents the absence of interdependency, while 1 represents maximum interdependency between the two themes.[63] For example, a low independency was considered 0.3, medium 0.6, and high 1.0.[63,64]

To rank the interdependency, the scores for each PHI theme were added. The total score for a row reflected the leadership index and the column score was the subordination index. The theme with the highest leadership index was considered the most important because if its functionality fails, the performances of health services for the community decrease dramatically. The theme with the highest subordination index had the greatest dependency on the other PHI within the community.[63] Both index scores for each theme were then added to provide the ranking. This process was conducted by four assessors: two clinicians (one with a humanitarian focus); an environmental health /disaster health professional; and a public health practitioner/academic.

The paper identified 13 thematic areas related to PHI and disasters with the workforce found to be the most important. If its functionality fails, it has the greatest impact on the performance of health services. If addressed post disaster, the remaining forms of PHI will then be progressively addressed. The findings provided an evidence base for exploring PHI priorities during the focus group and interview phase.

Literature review 3 – Impact of disasters on people with noncommunicable diseases

Publication – Ryan B, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2015). Identifying and describing the impact of cyclone, storm and flood related disasters on treatment management, care and exacerbations of non-communicable diseases and the implications for public health. PLOS Currents Disasters. 2015(7). Impact factor not available; Indexing PubMed and Scopus; Google Scholar citations 14.

This literature review built on the previous research by focusing on the impact of disasters on NCDs and is available in Chapter 3 and Appendix C. The aim was to identify and describe the impact of cyclone, flood and storm related disasters on those susceptible to, or experiencing, NCDs. A systematic literature review was used to complete the research.

The search terms were: "Cyclone", "storm" or "flood"; and "noncommunicable disease", "NCD", "chronic disease", "cancer", "malignant tumours", "neoplasms", "cardiovascular disease", "coronary heart disease", "cerebrovascular disease", "peripheral arterial disease", "rheumatic heart disease", "congenital heart disease", "deep vein thrombosis", "pulmonary embolism", "chronic respiratory diseases", "asthma", "chronic obstructive pulmonary disease", "COPD", "occupational lung diseases", "lung disease", "pulmonary hypertension", "diabetes"; and "disaster".

A search of CINAHL, Medline, PsycINFO, Science Direct and Scopus databases was conducted in January 2015 with a date limit of 31 December 2014. These databases were selected to maximise the literature searched and minimise the risk of missing relevant articles. To further maximise the scope of the literature examined, reference lists of obtained literature were reviewed. Google Scholar was considered as one of the databases, however, the publications are not listed in relation to quality, they are displayed in relation to visits.[65] Also, the retrieval and record management mechanisms lack quality when compared to other

databases.[66,67] For these reasons, Google Scholar was only used to explore reference lists and citations of obtained literature.

The review found cyclone, flood and storm related disasters impact on treatment management and care for people with NCDs. Possible consequences include exacerbation of illness, complications or even death. The findings highlighted the need for the focus groups and interviews to help understand the factors that influence both direct and indirect (preventable) morbidity and mortality related to NCDs during and after disasters.

2.4.4.2 Phase two – Focus groups and interviews

This phase included focus groups and interviews with: disaster service providers; and people with NCDs. The aim was to investigate the impact of cyclone, flood and storm related disasters on PHI and NCDs, and identify mitigation strategies. The objectives were: identify and describe the impact of disasters on PHI and the management of NCDs; investigate the knowledge and experience disaster service providers have about the impact of disasters on PHI and the management of NCDs; investigate the impact disasters can have on people with NCDs; and identify how the risks identified can be mitigated.

There were six focus groups and 42 interviews with a total of 105 participants. This included five focus groups with environmental health professionals and one with disaster service providers. There were 31 interviews with providers and 11 interviews with people who had a NCD. The qualitative analysis was undertaken based on Creswell's (2013) book titled *Qualitative Inquiry and Research Design*, which was the mandatory text for the Qualitative Research Methods course completed as part of the PhD.[1]

The information from interviews and focus groups was transcribed and thematically analysed using a combination of electronic analysis in QSR NVivo 10 and Microsoft Excel™. This included data organisation, reading and memoing, data description, data classification and an interpretation of the findings[1]:

1. Organising data: the focus group and interviews were tape recorded and then transcribed. After transcription the data was saved electronically and then uploaded to QSR NVivo 10.

2. Data description: A description of the data was developed based on the key phrases, ideas and concepts. Interview participants were allocated a de-identified code, for example, *I1*, and focus group data was referred to as *FG*. Firstly, "lean coding" was used to analyse the data in QSR NVivo 10. This is where a short list of tentative codes are used to analyse the data and then expand and/or group into families. The codes used were based on the descriptions of PHI, and NCDs; mitigation strategies; and negative, positive and neutral impact of flood and storm related disasters on PHI, and NCDs. Secondly, the codes were then placed in a Microsoft Excel™ spreadsheet to develop an individual description based on key phrases, ideas and concepts.
3. *Data classification and interpretation:* The data was classified through manual aggregation of individual descriptions and themes in a Microsoft Excel 2010™ spreadsheet to create an overall case description. QSR NVivo 10 was not used for this process because computer assisted systems pose challenges in determining meaningful themes as they are not designed to synthesise data and interpret the meanings.[68] Ultimately, the quality of interpretation is determined by the rigor of the procedures employed by the researcher not the software. For these reasons the data was analysed manually according to the: impact of disasters on PHI; the relationship between PHI breakdown after a disaster and NCD risks; and mitigation strategies.

Throughout this process, the data was constantly compared to understand and validate the emerging theory by moving between the data, memoing and data analysis to ensure the theory was valid and an abstract account of the data.[1,69,70]

Two papers were published and report written from this phase of the research. The papers focused on: environmental health professionals (via focus groups)[31]; disaster service providers (via interviews and a focus group)[32]; and the report style paper on people with NCDs (via interviews). This approach was taken because each group has a unique, discrete and important perspective, for example, the environmental health profession addresses risks relate to drinking water, sanitation, food safety and mass gatherings.[25,58] Disaster service providers are responsible for overall leadership, designing and managing system-wide preparation, prevention, response and recovery phases of disaster management.[57] Meanwhile, people with NCDs represent the group at greatest risk of disease exacerbation if impacted by a disaster.[27] Combing these groups into one research paper would have greatly missed the individual

challenges, nuances and recommendations being understood and placed on each group. An overview of each paper is provided in the following.

> *Paper 1 – Environmental health perspective on public health infrastructure and noncommunicable disease management*
>
> *Publication – Ryan B, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2017). The role of environmental health in understanding and mitigating post-disaster non-communicable diseases: The critical need for improved multidisciplinary solutions. Journal of Environmental Health. Vol 80(5):38-50. Impact factor 0.927 (Thomson Reuters 2017); Indexing CABI, EBSCOhost, Elsevier BV, Gale, H.W. Wilson, International Atomic Energy Agency, National Library of Medicine, OCLC, Ovid, Pan American Health Organization, ProQuest, Safe Publications, Thomson Reuters and U.S. National Library of Medicine; Google Scholar citations 3.*

The aim was to explore current and potential roles of environmental health professionals in helping understand and mitigate the impact of disasters on people with NCDs. This paper is available in Chapter 4 and Appendix D.

Data was collected through five focus groups with 55 participants from March to August 2014 in Queensland, Australia. Two focus groups were held in the South-West of the State (Roma) and three in North Queensland (Malanda (n=2) and Townsville (n=1)). The interviews were transcribed and the data analysed through the phases of: organising data; data description; and data classification and interpretation.[1,18,69]

A questionnaire was developed to guide the discussion and help focus on understanding the direct role environmental health professionals could have in mitigating the impact of disasters on people with NCDs. The questions related to the participant's experience in disaster management; examples of PHI and the relationship with NCDs; how disasters can impact on people with NCDs; mitigation options; and the role of environmental health.

A purposive sampling strategy was used to select and recruit participants. Participants included officers, environmental health academics, professionals and specialists (referred to as "environmental health professionals"). This group was selected because their perceptions, experiences and activities are considered crucial in influencing disaster preparations, responses

and recovery for cyclone, flood and storm related disasters. For example, in a disaster situation, particularly in Queensland, Australia, the profession works across and with disciplines to address risks relating to: drinking water; hazardous; general waste; sanitation; food safety; communicable diseases; vector issues; and mass gatherings.[58,71] All of which can be considered vital for maximising treatment, care and services for people with NCDs before, during and after a disaster.[71-73]

The principle of saturation was used to determine the number of focus groups.[1,74-76] The point of saturation was achieved after four focus groups. The fifth focus group did not generate any new information.

Relationships were identified between NCD exacerbation and PHI, such as power; sanitation; services; supplies; and water. Preparedness and response activities should focus on priority PHI, which will require environmental health professionals to be part of interdisciplinary solutions. The findings provided an evidence base, from the perspective of environmental health professionals, for constructing the modified Delphi process.

> *Paper 2 – Disaster service provider perspective on public health infrastructure and noncommunicable disease management*
>
> *Publication – Ryan B, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2016). Reducing disaster exacerbated non-communicable diseases through public health infrastructure resilience: perspectives of Australian disaster service providers. PLOS Currents: Disasters. Dec 21, Edition 1. Impact factor not available; Indexing PubMed and Scopus; Google Scholar citations 15.*

The aim was to explore the role of disaster service providers in reducing disaster exacerbated NCDs through PHI resilience. This paper is available in Chapter 4 and Appendix E.

Data was collected via 32 interviews and one focus group (eight participants) between March 2014 and August 2015 with 40 disaster service providers representing ten organisations. A questionnaire with a combination of structured and open-ended questions was developed by the research team to guide discussions.

The aim was to understand the role disaster service providers could have in maximising the treatment, care and services for people with NCDs during and after a disaster. The questions focused on: participant's examples of PHI; relationship between a breakdown of PHI, and poor health outcomes for people with NCDs; and mitigation strategies. The analysis included the phases of: organising data; data description; and data classification and interpretation.[1,18,68]

The research areas included: Cairns and Hinterland HHS; Darling Downs HHS; Townsville HHS All are located in the State of Queensland, Australia. Government officials with disaster management responsibilities in Brisbane (State Capital) were also included as their decisions directly influence PHI, management of NCDs and disaster responses.

The participants were recruited and selected using a purposive sampling strategy.[1] This included recruitment through professional networks, support organisations and the public domain using letters, e-mail, discussion with appropriate organisational representatives (for example, health professionals and NCD support organisations). A focus group was held in Townsville and interviews conducted in Brisbane, Cairns and Innisfail (Cairns and Hinterland HHS), Townsville (Townsville HHS) and Toowoomba (Darling Downs HHS).

The principle of saturation was used to determine the number of interviews.[1,74-76] For convenience a focus group was held in Townsville as part of a regional disaster meeting. The point of saturation was achieved after approximately 25 interviews. The focus group and remaining seven interviews did not generate any new information. The additional interviews were held to ensure all organisations and research locations had an opportunity to participate.

A relationship was found between the impact of a disaster on PHI and increased health risks for people with NCDs. Mitigation strategies were described for all phases of the disaster cycle impacting PHI. The findings combined with the perspective of environmental health professionals, provided a pattern of emerging themes such as the relationship between individual PHI and NCD exacerbation and possible mitigation strategies. These were used for constructing the modified Delphi process.

Report – Perspectives of people with noncommunicable diseases

Ryan B, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P. Patient perspectives on the role of public health infrastructure in reducing the risk of non-communicable disease exacerbation post natural disaster.

The aim of this pilot study was to explore from a patient's perspective how PHI could be used to mitigate the risk of NCD exacerbation after a natural disaster. This report style paper is available in Chapter 4.

The data was collected via 11 semi-structured interviews with people who had a NCD between May 2014 and September 2015. The number of interviews was determined by the principle of saturation and this was reached after ten interviews.[1,74] Interview 11 did not generate any new information. A thematic analysis was undertaken and included the phases of: organising data; data description; and data classification and interpretation.[1,18,74]

Interviews were guided by open-ended questions. The focus was on discussing and providing a better understanding of both the perceived objective and subjective impact of disasters on PHI; the relationship between PHI breakdown after a disaster and NCD exacerbation; and mitigation strategies.

Participants included people with cardiovascular diseases, cancers, chronic respiratory diseases, diabetes and renal conditions. Recruitment occurred through professional networks, NCD support organisations and the public domain. This included letters, e-mail and discussion with appropriate organisational representatives and public advertising used, such as advertising notice boards at health care facilities and radio interviews. The research occurred within the geographical areas of the Cairns and Hinterland HHS, Darling Downs HHS and Townsville HHS in Queensland, Australia.

This study identified strategies for reducing the exacerbation of NCDs post disaster. The findings continued to build an evidence base, from the perspective of people with NCDs, for constructing the modified Delphi process.

2.4.4.3 Phase three – Modified Delphi process

The aim was to quantify, evaluate and prepare mitigation strategies that could reduce the exacerbation of NCDs before, during and after a disaster. A modified Delphi process was used to achieve this aim. The objectives were:

- Engage a disaster health expert group through a questionnaire to identify the mitigation strategies from the focus groups and interviews that should be kept, removed or clarified.
- Conduct a workshop with a disaster health expert group to discuss questionnaire feedback and finalise mitigation strategies for the ranking and prioritising process (survey).
- Survey disaster service providers and people with NCDs to rank and prioritise PHI concerns and mitigation strategies for maintaining treatment, care and services during and after a disaster.
- Develop mitigation strategies.

A modified Delphi process was selected because it provided the opportunity to explore the research more deeply in different ways and develop mitigation strategies (proposed solution) ready for translation into practice.[76] The Delphi process is based upon the assumption of safety in numbers (for example, several people are less likely to arrive at a wrong decision) and is useful in gathering opinions.[77] It is a flexible approach used commonly in health and social sciences to transform opinion into group consensus.[77] The modified Delphi process aligned with how this study was the final phase of a broader project that used the Promoting Action on Research Implementation in Health Services (PARIHS) framework to focus on developing mitigation strategies for reducing the risk of disaster exacerbated NCDs.[78] PARIHS has previously been successfully applied by health professionals to implement evidence into practice.[79] It includes three elements for effective implementation, evidence base (literature reviews, focus groups and interviews), context (disaster risk for study location and Sendai Framework) and facilitation of whole system change (this paper – modified Delphi process).[80] An overview of the paper is provided in the following.

Paper – Ranking and prioritising mitigation strategies

Publication – Ryan B, Franklin R, Burkle F, Aitken P, Smith E, Watt K & Leggat P (2018). Ranking and prioritizing strategies for reducing mortality and morbidity from noncommunicable diseases post disaster. International Journal of Disaster Risk Reduction. Vol 27:223-238. Impact factor 1.603 (Thomson Reuters 2017); Indexing EBSCOhost, Elsevier BV, Gale, National Library of Medicine, Ovid, ProQuest and Thomson Reuters; Google Scholar citations nil.

The aim was to rank and prioritise mitigation strategies based on the perspectives of people with NCDs and disaster service providers. This paper is available in Chapter 5 and Appendix F.

Data was collected in Queensland, Australia, through three sequential phases between September and December 2016. This included: questionnaire (n=14) to recommend mitigation strategies for the survey phase; workshop (n=18) to explore questionnaire results; and survey (n=552) to rank and prioritise the mitigation strategies.

The participants for the questionnaire and workshop phases were disaster health experts (this occurred on 5 and 6 September 2016, respectively). The group completed a questionnaire focused on determining if each of the 76 mitigation strategies, adapted from earlier research (focus groups and interviews), should be kept, removed or clarified. Where participants indicated clarification was required, group discussion occurred at the workshop to determine if the strategy should be reworded and kept, removed or even if another should be added. The decision on removal, clarification and addition of a mitigation strategy was determined when consensus was achieved, which is consistent with the Delphi process[81]. The workshop was designed to allow open creative discussion, which also provided the opportunity for participants to recommend additional mitigation strategies. The finalised mitigation strategies were included in the survey.

The research identified 31 mitigation strategies across 12 PHI themes. Access to safe water should be the first priority for people with NCDS post disaster. The next priorities, in order, should be strategies related to communication, sanitation, workforce, supplies, power, equipment, physical structure, services, governance, prevention and finance. All mitigation strategies are interrelated and together provide a theoretical basis for addressing this problem.

2.4.5 *Ethics*

Ethical approval was provided for focus groups and interviews from both James Cook University (H4871) and Townsville HHS Human Research Ethics Committee (HREC/13/QTHS/251). Ethical approval was provided for the modified Delphi process by both James Cook University Human Research Ethics (H6646) and the Townsville HHS Human Research and Ethics Committee (HREC/16/QTHS/67). The ethical approvals were complemented by letters to relevant organisations seeking permission to invite staff and people with NCDs to participate in the different research phases.

2.5 Conclusion

This chapter described the aims and objectives, theoretical paradigm, research strategies and the methods of collection and analysis. This included a description of the philosophical assumptions, five approaches to qualitative research, justification for the constructivist narrative approach and an overview of the study methods, regions and participants. A mixed methods sequential exploratory design was used to complete the research. Thematic analysis techniques were used to analyse the qualitative data and a combination of descriptive statistics and chi-square tests with a Bonferroni-adjustment were used for the quantitative components. The research design allowed emerging themes to be ranked, prioritised and explored more deeply in different ways to develop mitigation strategies that are ready for implementation. The first phase of the research, the literature reviews are described in the next Chapter.

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Chapter 3 Literature Reviews

3.1 Overview

The impact of disasters on public health infrastructure (PHI) and the management of noncommunicable diseases (NCD) was explored through three literature reviews.[1-3] The first investigated the impact of Australia's Severe Tropical Cyclone Yasi on PHI and the management of NCDs, with a comparative analysis to similar events across the world (3.2). The second defined, described and categorised PHI priorities for cyclone, flood and storm related disasters (3.3). The final paper identified the impact of cyclone, flood and storm related disasters on people with NCDs (3.4). This Chapter describes these interrelated papers and present a synthesis of how the findings create the platform required to complete the next phase of the research, focus groups and interviews.

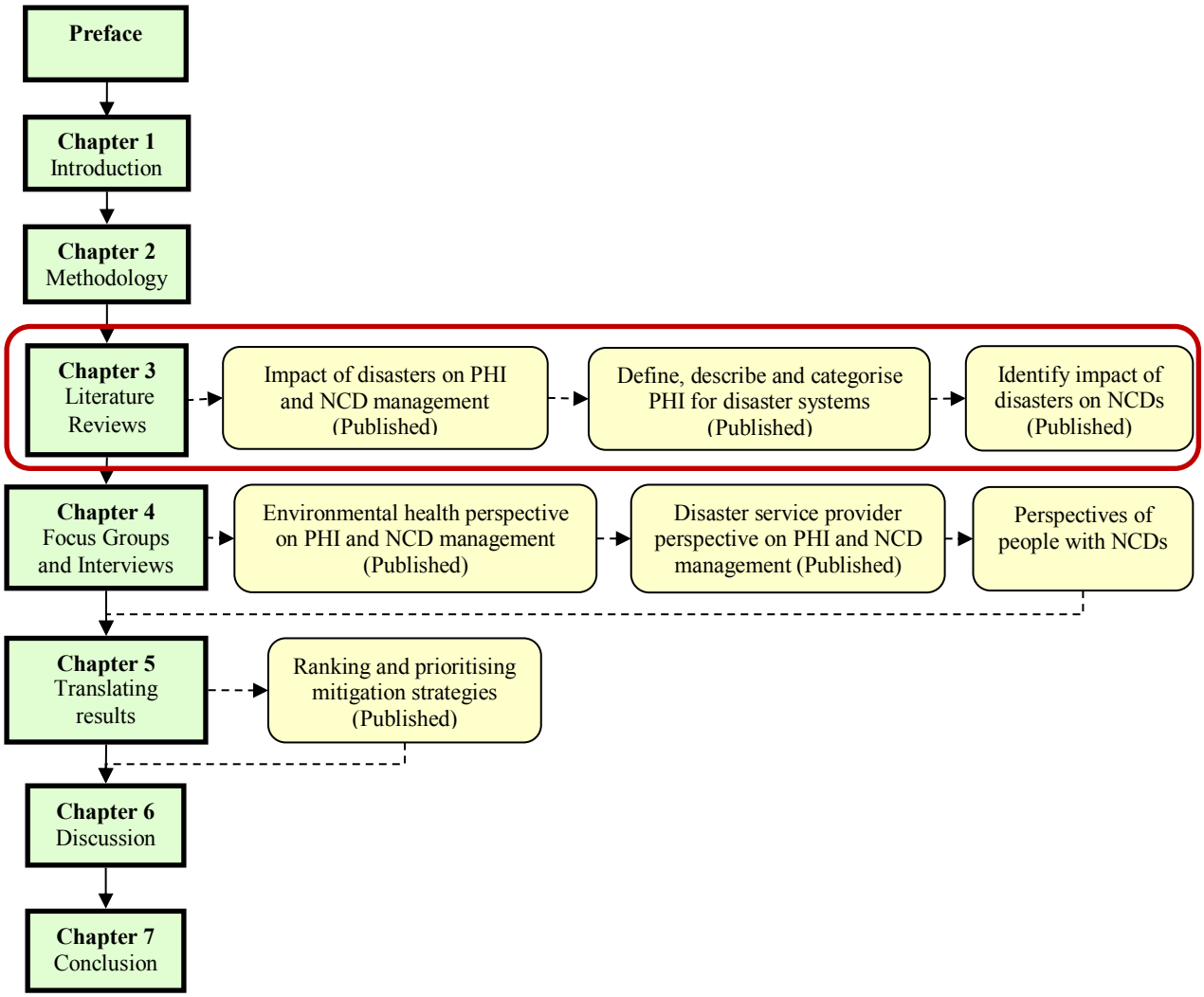

Figure 3-1 Chapter 3 position within thesis

3.2 Impact of disasters on public health infrastructure and noncommunicable disease management

Published – Ryan BJ, Franklin RC, Burkle FM, Watt K, Aitken P, Smith EC and Leggat P (2015). Analyzing the impact of severe tropical Cyclone Yasi on public health infrastructure and the management of non-communicable diseases. Prehospital and disaster medicine. Vol 30(1):1-10. Impact factor 1.03 (ResearchGate 2015); Indexing ESCI, National Library of Medicine, Scopus, OCLC, Ovid, Pan American Health Organization, ProQuest, Safe Publications, Thomson Reuters and U.S. National Library of Medicine; Google Scholar citations 14 – Appendix A.

3.2.1 *Introduction*

Globally, the frequency of natural disasters has been increasing in the last quarter century, with the majority resulting from weather, climate extremes and water related hazards.[4] While there have been more than 3.4 million lives lost in this period, the death rates are decreasing, while the number of people affected is increasing.[5] For example, the death rate per one million people from 1900 to 1989 was 94 compared to five between 1990 and 2006 (a decrease of 95%).[6] During 2002 to 2011 the annual average number of deaths from disasters was 107,000, while the number affected was 68 million, one death per 635 people affected.[7] This ratio highlights the need for disaster systems to focus resources on assisting those affected by a disaster.

Following a disaster, public health activities have traditionally focused on communicable diseases, however, the actual risk is low, particularly in developed countries.[8] Furthermore, population ageing and an increase in life expectancy have contributed to a "disease transition" from communicable diseases to noncommunicable disease (NCDs).[9] This transition has imposed major burdens on health care resources as they are more dependent on immediate access to public health infrastructure (PHI) and are costly to treat, both of which have implications for disaster management.[10,11]

NCDs are an increasing challenge across the globe.[12] Across Australia, NCDs (or chronic diseases) cause 88% of the burden of disease, 91% of all deaths and cost 87% of recurrent health expenditure.[13] In Queensland, Australia, the bulk of ill health, disability and premature death arise from NCDs.[14] Common NCDs in Queensland are cancer, cardiovascular disease,

chronic respiratory diseases, diabetes and renal diseases.[15] NCDs are responsible for 39% of premature deaths (before 75 years of age).[13] Naturally occurring disasters are a feature of the climate and landscape in Queensland and this threat is predicted to increase with climate extremes expected to make weather events such as cyclones and floods more frequent.[16,17] There is a need for more research in NCDs within the disaster management space to prepare for future events.

People with NCDs need access to good PHI and require long-term medication, life-support devices and close case follow-up.[9] PHI can include staff, medications, equipment, services, housing, water, food, waste, sanitation and power/energy to run life sustaining equipment.[18-21] When PHI is destroyed, rendered inaccessible or damaged, access to chronic care treatment and medication may be severely jeopardised, all which can exacerbate NCDs, their immediate and sustained quality of care outcomes, as well as mortality and morbidity.[22]

To help address these risks, this research explored the impact of Severe Tropical Cyclone Yasi on PHI and management systems of NCDs. Linkages with other worldwide tropical cyclone literature was explored to identify if there have been similar impacts. This provided a process of validation to better understand the impact of disasters and also determine if the findings could be extrapolated for future crises.

3.2.2 *Methodology*

The databases searched were CINAHL (EBSCO; Ipswich, Massachusetts USA), Google Scholar (Google, Inc; Mountain View, California USA), Google and Medline (Medline Industries, Inc; Mundelein, Illinois USA). The first phase focused on identifying, reviewing and analysing literature discussing the impact of Severe Tropical Cyclone Yasi on PHI and the management of NCDs. The second phase identified potential linkages with non-Severe Tropical Cyclone Yasi studies by analysing the impact of other worldwide tropical cyclones (including hurricanes and typhoons) on NCDs. The second phase included non-Severe Tropical Cyclones due to the limited peer-reviewed research in this area.

A two-phase process was selected as this provided the best mechanism for comparing a disaster, which resulted in Australia's largest hospital evacuation, with other weather events across the world. In addition, this method provided a process of validation and determining if the findings could be extrapolated to other similar disasters (Figure 3-2).

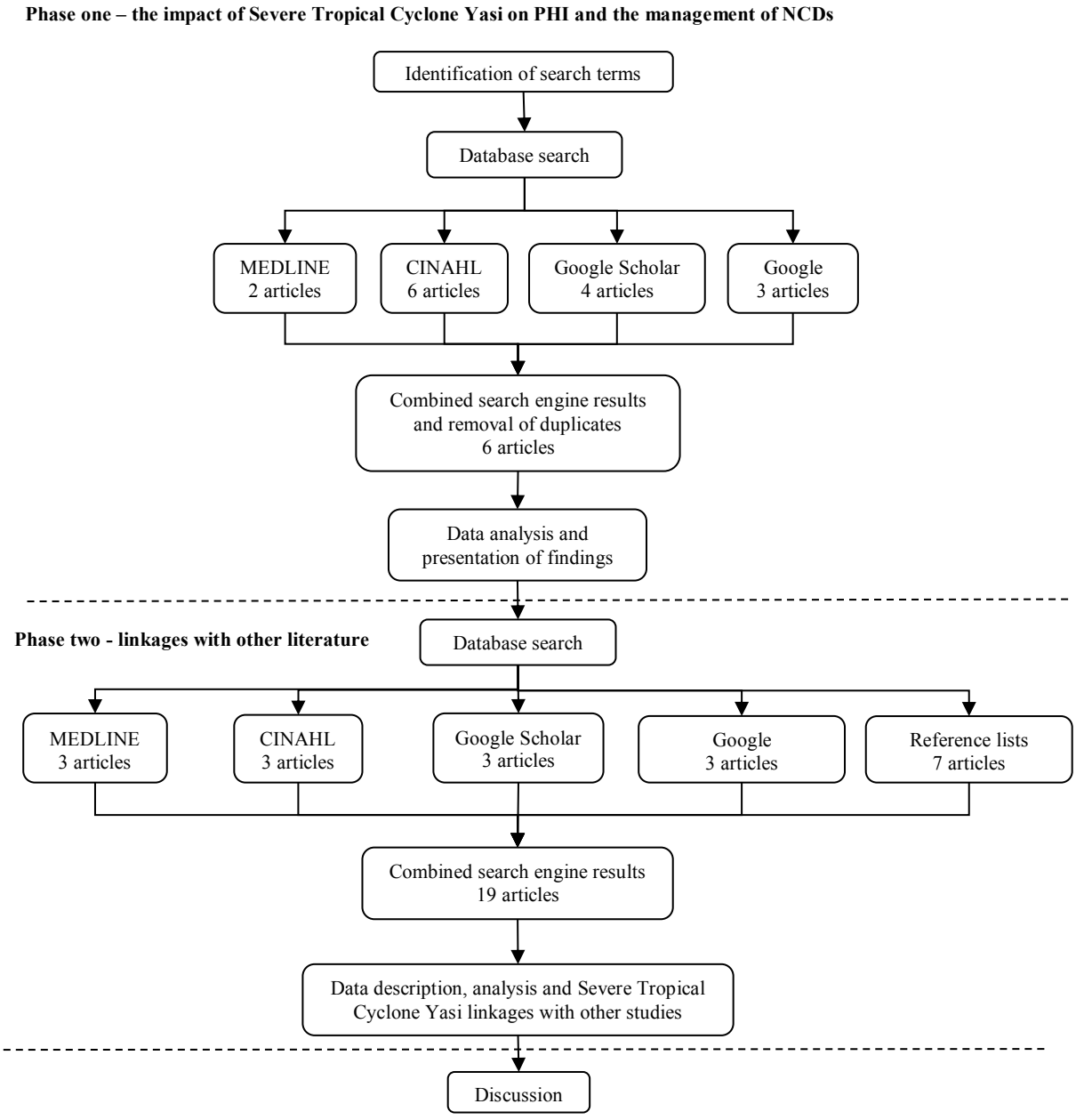

Figure 3-2 Research methodology

3.2.2.1 Phase one – the impact of Severe Tropical Cyclone Yasi on PHI and the management of NCDs

CINAHL, Google Scholar, Google and Medline databases were searched in May 2013. The date range was 26 January 2011 to 2 May 2013. Initially the search combined the terms "cyclone Yasi", "public health infrastructure" and "noncommunicable diseases". This search found no relevant articles. The search was then expanded to include the most common NCDs in Queensland, Australia, (cancer, cardiovascular disease, chronic respiratory diseases, diabetes and renal diseases) and the term "chronic disease".[15] Searches were conducted without the phrase "public health infrastructure". An article was considered valid if the inclusion criteria were achieved, which included: literature meeting the search terms; events a week prior Severe Tropical Cyclone Yasi and four weeks after. Abstracts that did not include Severe Tropical Cyclone Yasi and NCDs were excluded.

The data analysis followed the process for a qualitative case study outlined by Creswell (2013).[23] This included data collection and organisation, data description, data classification and an interpretation of the findings. Each process is described in the following:

1. *Data Collection:* the databases were searched using the search terms of "cancer"; "cardiovascular disease"; "chronic respiratory diseases"; "diabetes"; "renal diseases"; or "chronic disease"; and "cyclone Yasi". Selected articles were analysed by hand.[23] Key phrases, ideas and concepts were identified.
2. *Data description:* a description of the data was established based on the key phrases, ideas and concepts identified during data collection. The data was coded based on the common NCDs in Queensland.[13]
3. *Data classification and interpretation of the findings:* the data was classified through an aggregation of individual descriptions and themes to create an overall case description. The data was reduced to a set of themes, which classified, described and used to interpret the findings. The interpretation was used to understand what could be learned and inform phase two of the research.

3.2.2.2 Phase two – linkages with other literature

To ensure consistency with phase one, a database search was also conducted using the CINAHL, Google Scholar, Google and Medline databases. The search occurred on 5 July 2013 and included the terms "cyclone", "hurricane" or "typhoon" and NCDs subject to the research in phase one (cancer, cardiovascular disease, chronic respiratory disease, diabetes and renal diseases), with no time limits applied to the search. A search was also undertaken using the term "chronic disease" to maximise literature identified. Initially the term "public health infrastructure" was omitted to provide consistency with the method used for Severe Tropical Cyclone Yasi. This strategy was effective in all databases, however, a test search for cancer in Medline resulted in 1,600 articles. Therefore, the term "public health infrastructure" was applied to the search in the Medline database.

An article was considered valid if the inclusion criteria were achieved. This included: literature (abstracts) meeting the search terms; events the week prior to a cyclone and the four weeks after;[22] and literature referring to Severe Tropical Cyclone Yasi was excluded as they were already searched. No other geographical, time or language limits were applied. Reference lists were also reviewed to identify relevant literature. The selected literature was then analysed and compared with the themes from phase one.

3.2.3 *Results*

3.2.3.1 Phase one – the impact of Severe Tropical Cyclone Yasi on the management of NCDs

3.2.3.1.1 Data collection

The search strategy identified six relevant documents (Table 3-1). The CIHNAL database was the most effective in identifying relevant articles (n=6). The most common search term across all databases was "renal diseases" (n=5). After a removal of duplicates, six articles (literature) were found. No variations in the disease definitions were identified.

Table 3-1 Search results for phase one

Search Term	Google Scholar	CIHNAL	Medline	Google
Cancer	1[21]	-	1[21]	-
Cardiovascular disease	-	1[24]	-	-
Chronic respiratory diseases	-	1[24]	-	-
Diabetes	-	-	-	-
Renal diseases	2[21,25]	3[24,26,27]	1[26]	3[26-28]
Chronic disease	1[25]	1[24]	-	1[29]
Total	**4**	**6**	**2**	**3**

Combined with duplicates removed: 6 articles

3.2.3.1.2 Data Description

A matrix was developed to provide an individual case description for each article and identify the key themes (Table 3-2). Four of the articles focused on the evacuation of patients from Cairns to Brisbane (Queensland, Australia). One article discussed the experiences of The Townsville Hospital Renal Dialysis Unit and another focused on the work of the Queensland Kidney Support Network. The need for a staging area for patients prior to an evacuation and the challenges in meeting nutritional needs were also discussed. Other issues included the transfer of patient information, maintaining patient care and communicating specific disaster information to people with a chronic disease. The themes of communication, equipment and services, evacuation, medication, planning, renal diseases/dialysis and access to water for dialysis emerged from the literature.

Table 3-2 Description of Severe Tropical Cyclone Yasi literature

Article	Description	Themes
Hayes (2011)[26]	The author described her experiences at the Cairns Renal Unit during the evacuation of patients to Brisbane, Queensland, Australia.	Communication; planning; renal patients
Johnson et al (2013)[25]	The article discussed the responses of dialysis services to Severe Tropical Cyclone Yasi and the south-east Queensland floods in 2011.	Communication; renal diseases; equipment and services; planning; water
Little et al (2012)[21]	This article described the events around the evacuation of patients from Cairns hospitals to Brisbane, Queensland, Australia.	Communication; equipment and services; evacuation; planning
Rossi et al (2011)[24]	The article recounted the nutritional challenges faced by 71 dialysis patients evacuated from Cairns to Brisbane. Communication was an issue with patients arriving without medications and information despite local emergency policies.	Communication; renal diseases; evacuation; renal diseases; planning
Schafer (2011)[28]	The article reports on the work of the Queensland Kidney Support Network during the Queensland floods and cyclones of 2011. The limitation of medical facilities with dialysis spaces was discussed.	Communication; renal diseases; planning; services
McArdle (2011)[27]	The experiences from The Townsville Hospital Renal Unit were discussed. The potential impact on patients was identified and resulted in amending schedules to maximise treatment opportunities.	Communication; planning; renal diseases; water

3.2.3.1.3 Data Classification and interpretation of findings

The data gathered was classified into the themes that emerged during the description process. Each theme was analysed across the articles and then used to interpret the findings and understand the results.

1. Communication: challenges were identified during the transfer of patient information from Cairns to Brisbane. Telecommunications systems were unable to cope with the situation. E-mail was the most efficient and effective means of communication. In the future, communication systems need to be refined to ensure patient information can be easily transferred and coordinated.[21,24-28]

2. Equipment and services: the evacuation of patients from Cairns to Brisbane created challenges for maintaining services (including staff levels) and equipment (for example, oxygen and medications). No planning had been undertaken for an evacuation of this type or the operation of a temporary emergency shelter. Adequate staffing was also an issue as people affected by the cyclone were asked to work. In the future, additional staff should be sourced from outside the area subject to the disaster and equipment prepositioned.[21,25,28]

3. Evacuation: the greatest impact was on the evacuation of patients from Cairns to Brisbane. This was the largest hospital evacuation in Australia's history and posed a number challenges, particularly the transfer of patient information (communication). For evacuations in the future, there needs to be adequate and exercised plans, effective communication systems and a casualty clearing post for patients awaiting transfer. Patients also need to be prepared for a one week transfer.[21,26]

4. Planning: there was inconsistency in disaster plans. For example, the Cairns Renal Unit had a disaster plan, which identified the need to retrieve patients from an Indigenous community near Cairns. However, another Hospital and Health Service's disaster plan did not provide such guidance. This created a number of risks, particularly as priorities were identified during the event. This experience highlighted the need for disaster plans to be developed in consultation (including with patients), regularly reviewed, exercised and relevant for the entire health system.[24-28]

5. Renal diseases/dialysis: renal diseases were identified as the main illness of concern before and after Severe Tropical Cyclone Yasi. This was due to the need to maintain treatment for high-need dialysis patients. The level and quality of planning, preparedness and response varied across Queensland. In the future, disaster plans should consistently focus on patient hazards, such as missed dialysis sessions and

diet. Also, an assessment of renal facilities (including water treatment systems) after a disaster and before re-opening should be a priority.[24,26-28]

6. Water: Access to safe water is vital for dialysis and hydrating patients. For example, the Townsville Renal Unit began planning to evacuate due to a city-wide power outage, which reduced town water supplies to emergency levels. This risk was averted when power was rapidly restored. However, this issue highlighted the need to maintain access to safe water supplies for patients requiring dialysis and hydration.[25,27]

3.2.3.2 Phase two – linkages with other studies (peer-reviewed and theoretical)

3.2.3.2.1 Data collection

There were 19 articles identified, 12 using the search terms and seven from the reference lists of the selected articles (Table 3-3). The most frequent search term was "chronic disease" (n=10). No variations in the disease definitions were identified.

Table 3-3 Search results for phase two – linkages with other studies

Search Term	Google Scholar	CIHNAL	Medline	Google	Additional literature from reference lists
Cancer	-	-	1[30]	-	-
Cardiovascular disease	-	-	-	1[31]	-
Chronic respiratory diseases	-	-	-	-	-
Diabetes	-	1[32]	-	-	3[33-35]
Renal diseases	-	-	-	-	3[29,36,37]
Chronic disease	3[38-40]	2[41,42]	2[43,44]	2[45,46]	1[47]
Total	**3**	**3**	**3**	**3**	**7**

Total: 19 (12 from search engines and seven from reference list)

3.2.3.2.2 Data description, classification and linkages with Severe Tropical Cyclone Yasi

A matrix was developed to provide an individual case description for each article and identify the key themes (Table 3-4). The analysis found a number of linkages with the themes identified from Severe Tropical Cyclone Yasi. The linkages included communication, equipment and services, evacuation, planning and water. However, an additional issue emerged, the economic impact a disaster may have on people with NCDs and the health system.

Table 3-4 Description of literature from other studies

Article	Description	Themes
Kopp et al (2005)[29]	Describes the lessons from the 2005 hurricane season in the USA and the impact on kidney patients. Includes recommendations for continuing medical care.	Communication; evacuation
Taylor et al (2007)[43]	Describe the outcomes of a response of federal, state, county and local agencies in delivering medical care to persons affected by Hurricane Wilma through the use of mobile medical units.	Communication; services; planning
Motoki et al (2010)[41]	The article discusses the development of an information pamphlet for patients with diabetes, rheumatic diseases, chronic respiratory disease and dialysis.	Communication
Rolle et al (2011)[44]	The paper discusses investigations into responses to emerging infectious and non-infectious disease outbreaks, assisting in disaster response and evaluating core components of public health programs worldwide. The data provides information upon which global health policies and regulations can be based.	Communication; equipment an supplies
Keim (2008)[38]	Discusses the role of public health in reducing human vulnerability to climate change within select examples for emergency preparedness and response.	Communication; equipment and services; water; evacuation; economic

Scheuren et al (2007)[39]	Provided an overview of global disater numbers and trends.	Equipment and services
US Senate (2006)[45]	A report reviewing and recommending changes to the emergency response system in the USA to prompt effective relief when disaster strikes again.	Equipment and services
Alson et al (1993)[33]	The article explores what medical care was required for a special operations response team when a community is devastated by a major hurricane. It was a retrospective analysis of a field hospital set up after Hurricane Andrew.	Equipment and services
Leonard et al (1997)[34]	Discussed medical outreach operations and lessons from hurricane Marilyn	Equipment and services
Gavagan et al (2006)[30]	Describes the set up and operation of a medical facility at the Astrododome / Relain Center Complex in Houston after Hurricane Katrine. This includes the scope of the medical response, major challenges, successes and recommendations.	Evacuation; planning
Alderman et al (2012)[40]	Assesses epidemiological evidence on the impacts of floods on human health. Published articles (2004–2011) on the quantitative relationship between floods and health were systematically reviewed.	Equipment and services; evacuation; planning; water; economic
Lee et al (1993)[46]	This article discusses an outreach program that was implemented for medical care on St. Thomas Island after Hurricane Marilyn in 1995.	Planning
Doocy et al (2013)[31]	Describes the impact of cyclones in terms of mortality, injury, displacement and risk factors associated with these outcomes.	Evacuation; economic
Hendrickson & Vogt (1996)[35]	This study compared mortality data for the 5 years preceding Hurricane Iniki with mortality data for the 12 months immediately following. There was a focus on patients with diabetes.	Planning
Burkle (2007)[47]	Describes the impact of disasters on the public health systems and its protective infrastructure. This includes the impact this has on people with chronic diseases.	Planning

International Society of Nephrology (2013)[36]	Outlines the role of the Task Force in managing patients with acute renal failure after a disaster. There is a focus on pre-planning for a disaster to ensure continuity of services.	Planning
Miller & Arquilla (2008)[42]	Assess the burden of chronic renal failure, diabetes, and cardiovascular disease during disasters due to natural hazards. This includes identifying impediments to care, and proposes solutions to improve disaster preparation and management.	Planning; water
Picoli et al (2005) [37]	This article discusses the risk blackouts and other natural catastrophes pose to water supply and dialysis treatment. Dialysis is considered the most widespread chronic life-saving therapy worldwide and is reliant on water.	Water
Fonseca et al (2009)[32]	Examines the impact of Hurricane Katrina on the health of people with diabetes.	Economic

The data gathered was classified into the themes that emerged during the data description process. Each theme was analysed across the articles and then used to interpret the findings and understand the results. An overview is provided in the following:

1. Communication: During the response to Hurricane Katrina (Louisiana and Mississippi, USA, 2005) communication was a significant issue. This resulted in staff being unable to contact patients and misinformation.[29] This was also an issue during Hurricane Wilma (Florida, USA, 2005).[43] To address this issue it has been recommended communication strategies be targeted at patients with diabetes, rheumatic diseases, chronic respiratory diseases and renal diseases.[41] A common link was the need to ensure patient information is transferred and coordinated. An additional issue was the need for specific communication strategies between hospitals, public health officials and for different NCDs.[29,41,44] Health communications can also raise public awareness of evacuation routes, flood zones, and community response plans.[31]
2. Equipment and services: Hurricane Katrina destroyed health infrastructure and, in some cases, resulted in treatment interruption for four to six weeks.[39] Also, medical supplies were tailored for people with life-threatening conditions, however, many patients suffered chronic diseases.[45] As a result, many pharmaceuticals were

exhausted within one day of initiating operations.[45] This situation was not unique: following Hurricane Andrew (Florida, USA, 1992) insulin supplies were also exhausted within one day; insulin-loaded syringes were among the most needed supplies following Hurricane Marilyn (U.S. Virgin Islands) in 1993; and Hurricane Wilma in 2005 shut down health and social services (including home-based and elderly services) for 1.7 million people.[33,34,43] Overall, in the future, there is a need to have a ready supply of medicine, personal protective equipment and power generators for maintaining health services.[30,38,44]

3. Evacuation: The management of NCDs at evacuation shelters was a significant issue after Hurricane Katrina. For example, at the Astrodome/Reliant Center Complex in Houston (Texas, USA), the majority of clinic visits were for chronic disease or medication refills.[30,40] Another issue was the lack of a dialysis patient database and therefore no accurate estimate of the number of patients expected.[29] Generally, during disasters, evacuation of special populations, such as those in hospitals, schools, prisons, and nursing homes, as well as migrants, tourists, and people with disabilities, can create the need for a major public health intervention.[30,38,40,46]
4. Planning: Cyclones often exacerbate NCDs and rarely result in an outbreak of communicable diseases.[31] For example, after Hurricane Iniki (Hawaii, USA), in 1992, diabetes-related deaths increased 161% when comparing mortality data for the five years preceding with mortality data for the 12 months immediately following the hurricane.[35] One year after Hurricane Katrina there was a 47% increase in mortality (attributed to NCDs).[47] Input from relevant specialists should be sought in the future.[40] For example, the Renal Disaster Relief Task Force (RDRTF; Belgium) has been formed to respond to a range of disasters including Hurricane Katrina.[36] However, the response to the needs of diabetic and cardiac patients has been less rigorous.[42] Another need is the inclusion of mobile medical clinics in disaster preparedness, planning and response in the future.[40,43]
5. Water: during disasters, water shortages have been reported to affect a wide range of hospital services, including food preparation, environmental control, toilet availability, housekeeping, laundry, infection control and dialysis.[38] This risk increases when infrastructure is heavily impacted, populations are displaced and water supply systems are damaged, leading to the contamination of drinking water facilities.[40] Highlighting the importance is the quantity of safe water required for

dialysis (up to 120 L for a standard 4-hour treatment, or 360 L per week).[32,37,42] Therefore, if the water supply is compromised alternative options are required. This may include equipping dialysis centres with emergency plans for obtaining water.[37,42] The recommendations are consistent with the findings for Severe Tropical Cyclone Yasi.

6. Economic: cyclones and other meteorological hazards have been affecting an increasing number of people and have caused large economic losses.[31,38,40] For example, the economic impact of Hurricane Katrina on diabetes public patients was estimated at a US$5,243 increase over their lifetime, followed by Veterans Affairs patients US$3,907 and privately insured patients US$2,270.[32] This increase can be attributed to costs of diabetes-related complications due to the treatment disruptions.[32]

3.2.3.3 Comparing results

The results showed that the effects of Severe Tropical Cyclone Yasi on PHI, particularly with respect to NCDs were not significantly different from published experiences with other similar events in economically similar populations (Table 3-5).

Table 3-5 Comparison between Severe Tropical Cyclone Yasi and other studies

Severe Tropical Cyclone Yasi	**Other studies**
Communication	Communication
Equipment and services	Equipment and services
Evacuation	Evacuation
Planning	Planning
Renal diseases	Water
Water access for dialysis	Economic impact

The common themes for Severe Tropical Cyclone Yasi and other similar events were communication; equipment and services; evacuation; planning; and water (particularly for dialysis patients). A theme across the other studies, which was not identified from Severe Tropical Cyclone Yasi literature, was the economic impact of disasters. Although other studies

identified in the data collection were categorised as renal diseases, the analysis identified the issues raised cut across all diseases. For this reason, the other studies section did not have a specific theme for renal diseases.

3.2.4 *Discussion*

This study emphasised the growing importance of the indirect consequences of disasters, whether from war, conflict, or largescale natural disasters, which over time may dominate preventable mortality and morbidity rates. As such, there were two outcomes of interest. The first was to identify the impact of tropical cyclones on PHI and chronic disease. The second outcome of interest was to identify if there are trends across similar world events. The research demonstrated cyclones can impact on PHI and chronic disease, as well as a trend between the impact of Severe Tropical Cyclone Yasi and other similar world events on PHI and the management of NCDs.

A tropical cyclone (including a hurricane and typhoon) can negatively impact PHI, for instance, equipment (oxygen, syringes and medications), services (treatment, care and services) and water supplies and affect treatment and management of NCDs.[21,25,28,36,41,42,44] Although the impact of Severe Tropical Cyclone Yasi was not significant on PHI due to the location of landfall (a low-populated area between Cairns and Townsville), there were a number of lessons that can be extrapolated.[21] This review showed that the effects of Severe Tropical Cyclone Yasi on PHI, particularly with respect to NCDs, were not different from published experiences with other similar events in economically similar populations.

Communication to people with a NCD should be enhanced. Particularly, around patient information, needs (for example, nutrition), expectations, awareness of evacuation plans before an event and the risks associated with missed treatment (for example, dialysis). This could be achieved through fact sheets and discussions at the time of consultation or treatment in a disaster-prone area.[21,24-29,38,41,43,44]

Systems use for communication need to be enhanced to ensure sufficient patient information is transferred during an evacuation and services between different agencies are coordinated.[21,24-28] This could include exercises and training to ensure all parties are familiar with, and use, disaster management systems.[24-28]

This research has provided a lesson for disaster planning. A Severe Tropical Cyclone impacting a densely populated area could/would destroy PHI and result in an interruption to treatment regimes.[41] Therefore, disaster-planning activities need to reflect this possibility. Also, there needs to be renal dialysis disaster planning at the local hospital and health service level.[25,26,40,42,43] The planning should be based on current arrangements and how they can be maintained/increased using existing systems.

Access to safe water supplies is vital, particularly for dialysis treatment. It is important to ensure plans are in-place to sustain water supplies. This may include storage of additional water or arrangements with other facilities.[25,27,36,38,40,42]

For evacuations, there needs to be adequate and exercised plans, access to sufficient equipment (for example, medications and oxygen), and a casualty clearing post for patients awaiting transfer. Also, evacuation patients need to be prepared for a one-week transfer. This will reduce the risks associated with insufficient medication and allow expectations of people with NCDs to be managed.[21,24-26,29,30,35,38,40]

Additional staff should be sought from outside the area subject to the disaster to help those affected (for example, extra physicians, nurses and other health professionals). This could be addressed through workforce planning and familiarisation of work processes in different areas. Also, there needs to be prompt assessment of renal facilities before re-opening after disaster. This includes structural assessments and evaluations of power and water treatment systems.[21,25,28]

An interesting omission from articles was patient perspectives. This information needs to be sought because the findings of such research will ultimately inform structures from the bottom up for improving disaster knowledge, planning, policy, and practice.

There is also a need to explore the cost implications of disasters on people with NCDs and health systems. Although cost burdens were only identified for people diagnosed with diabetes affected by Hurricane Katrina, this finding provides evidence that disaster planning needs to focus on NCDs.[35] If this does not occur, there could be considerable financial implications for individuals, the community, and health systems.[31,32,38,40]

The findings have been used to conceptualise this relationship in Figure 3-3. This conceptual framework provides a platform for understanding the relationship between a disaster, PHI, and NCDs. It reflects the themes identified in the literature with communication now included as PHI. Disaster planners can use the framework to understand and identify areas for improvement and tailor plans accordingly. This could include enhancing PHI, such as ensuring access to safe water for dialysis patients through establishing alternative options and focusing on priority NCDs. This information could then be used to develop strategies for maintaining treatment, care and services after a disaster.

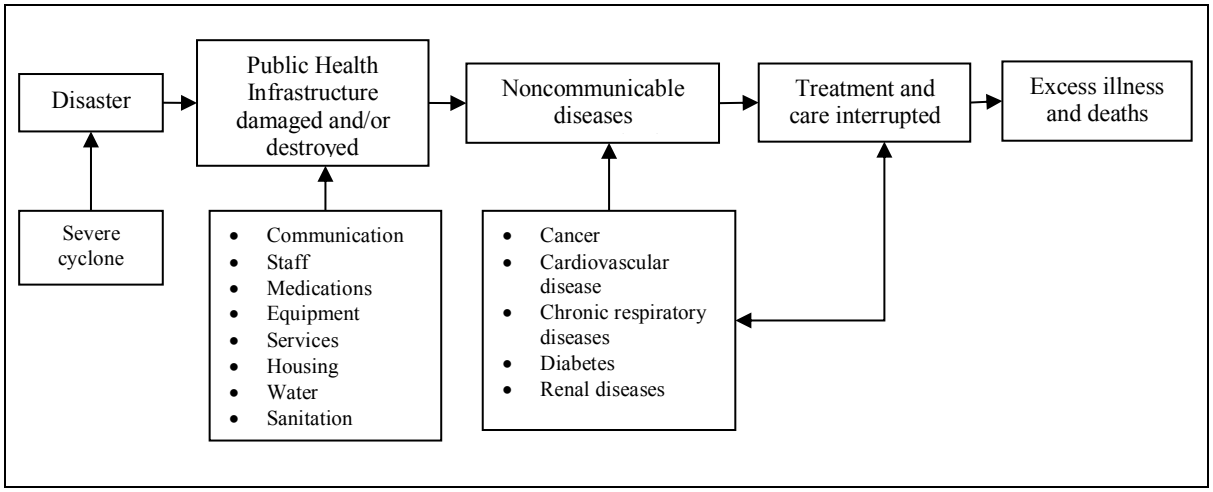

Figure 3-3 Conceptual framework: The impact of Severe Tropical Cyclone Yasi on public health infrastructure and noncommunicable diseases

A particular focus on PHI to address NCDs in the disaster setting is a novel idea. However, this research and the conceptual framework presented provide the platform for better tailoring of disaster plans, policy and practice. Few researchers in the area of disasters have addressed this issue.[31] Further studies should aim at identifying the true burden of natural disasters on NCDs and the relationship with PHI to inform disaster management systems.[41]

3.2.5 *Limitations*

The research was influenced by the lead author's studies and work in public health and disaster management at local, state, national and international levels. This experience could also influence the themes identified in the literature. However, all efforts have been made to prevent this from occurring by objectively analysing the literature. The selection of Severe Tropical Cyclone Yasi and a comparison to other similar disasters (hurricanes and typhoons) was based

on the size of the severity of the tropical cyclone, existing research and discussions with health professionals, disaster officers and other people affected by disasters.

As with any literature review, there is a risk of missing data and a lack of information related to non-peer-reviewed data. This highlights possible bias and reduces confidence that saturation of themes has been reached. To minimise this impact, a methodical literature review process was undertaken to research the issue.

Other limitations include the search terms and research methodology. The search terms were limited cyclone, typhoon, hurricane, cancer, cardiovascular disease, chronic respiratory diseases, diabetes and renal diseases. Also, comparison studies were restricted to mainly Hurricanes in USA (mainland and Hawaii), restricting the research to two health systems in developed countries.

3.2.6 *Conclusion*

The review showed that the effects of Severe Tropical Cyclone Yasi on PHI, particularly with respect to NCDs were not different from published experiences with other similar events in economically similar populations. The research found a tropical cyclone (including a hurricane and typhoon) can break down PHI, for instance, equipment (oxygen, syringes and medications), services (treatment, care and services) and water supplies and affect treatment and management of NCDs. The comparison between Severe Tropical Cyclone Yasi and worldwide tropical cyclones found the challenges faced were closely linked. These include communication, equipment and services, evacuation, medication, planning and water supplies. Additional issues emerged and include the need to seek patient perspectives through communication, consider the financial implications for people with NCDs, and the importance of disaster planning to encompass the entire health system spectrum.

This research provides an insight for disaster planners to address concerns of people with NCDs. While further research is needed, it provides an understanding of areas for improvement, enhancing protective public health infrastructure, development of strategies for maintaining treatment and alternative care options such as maintaining safe water for dialysis patients.

3.3 Defining, describing and categorising public health infrastructure for disasters

Published – Ryan BJ, Franklin RC, Burkle FMJ, Watt K, Aitken P, Smith EC and Leggat P (2016). Defining, Describing, and Categorizing Public Health Infrastructure Priorities for Tropical Cyclone, Flood, Storm, Tornado, and Tsunami-Related Disasters. Disaster Medicine and Public Health Preparedness. FirstView: 1-13. Impact factor 1.354 (Thomson Reuters 2017); Indexing Adis International Ltd., CABI, EBSCOhost, Elsevier BV, National Library of Medicine, Thomson Reuters and U.S. National Library of Medicine; Google Scholar citations 7 – Appendix B.

3.3.1 *Introduction*

Over the last quarter of a century the frequency of natural disasters has been increasing.[4] Of these, 88% have been the result of tropical cyclones (cyclones, hurricanes and typhoons), floods, storms, tornadoes and tsunamis, resulting in 76% of recorded deaths.[6,48] A disaster often results in the destruction and deterioration of public health infrastructure (PHI) such as food, health services, power, sanitation and shelter.[3,49] This jeopardises access to treatment and medication, which can further increase the indirect morbidity and mortality during and after a disaster.[20]

As a result of population growth, density, and rapid urbanisation of vulnerable populations, the risk disasters pose to PHI continues to rise.[15,16,50] For example, the southwest region of the United States of America is a fertile breeding ground for tornadoes.[51] Since 1950 there has been an average of 53 tornadoes and five deaths annually.[51,52] In Oklahoma, the urban sprawl has resulted in an increased number of people living in high risk tornado areas.[53] This risk will only increase as the population of Oklahoma is expected to increase from 3.9 million in 2013 to over 5 million by 2050.[53]

There has been scant research into the priorities for PHI of people living in disaster vulnerable areas. Understanding PHI priorities would benefit decision makers, disaster and health planners, health systems, and the community by systematically informing preparation, response and recovery priorities.

To help address this problem, a qualitative research literature review was conducted to better define, describe and categorise PHI according to the priorities for disaster management systems. The objectives included: defining PHI in the context of tropical cyclone (cyclone, hurricane and typhoon), flood, storm, tornado and tsunami related disasters; and categorising PHI priorities for these disaster types.

3.3.2 *Methods*

This qualitative research was completed using an integrative review method. This methodology was selected due to its effectiveness in defining concepts such as the definition, description and categorisation of PHI for disasters.[54,55] The method also allowed specific aspects of previous research to be critically and methodically evaluated.[56] To systematically achieve this, the research was completed in four stages: problem identification, literature search, data evaluation and data analysis.[54] The data evaluation and analysis was guided by the principles of qualitative research.[23] Each stage is discussed in the following.

3.3.2.1 Problem identification

PHI is not clearly defined, described and categorised to effectively inform preparation, response, and recovery activities for tropical cyclone, flood, storm, tornado, and tsunami related disasters. The focus on these events is because they account for 88% of disasters and result in 76% of disaster related deaths.[6,48]

3.3.2.2 Literature search

The literature search was conducted over three phases. The first focused on testing, refining and finalising the search terms in Medline. The second extended the search to other databases and the final was the selection of articles for analysis based on inclusion and exclusion criteria.

3.3.2.2.1 Testing, refining and finalising search terms

The search terms were determined through a process of testing, refining and finalising in Medline between September 2013 and December 2014. The Medline database was selected because it is a tool for biomedical, allied health researchers and practitioners conducting literature searches.[57,58]

Based on this process of testing, refining and finalising, the following search terms and methodology was used: “public health infrastructure”, “public health” or “infrastructure”; and “define”, “describe” and “categorise”; and “flood”, “cyclone”, “storm”, “hurricane”, “tornado”, “tsunami” or “typhoon”; and “disaster”.

3.3.2.2.2 Databases

Databases searched were CINAHL, Medline, PsycINFO, Science Direct, Scopus and Wiley Online. These databases maximised the literature searched and minimised the risk of missing relevant articles. An all field search was conducted between March and May 2014 by using the search terms with a date limit of 31 December 2013. Consistent with other literature reviews the search strategies used differed based on the database functionality (Table 3-6).[59]

Table 3-6 Searches conducted and terms used

Database	**Terms**	**Articles for review**
CINAHL	(public health infrastructure OR public health OR Infrastructure) AND (defin? OR descry? OR categor?) AND (cyclone OR flood OR hurricane OR storm OR tornado OR tsunami OR typhoon) AND disaster	19
Medline	(public health infrastructure OR public health OR Infrastructure) AND (defin$ OR descr$ OR categor$) AND (cyclone OR flood OR hurricane OR storm OR tornado OR tsunami OR typhoon) AND disaster	1,082
PsycInfo	(public health infrastructure OR public health OR Infrastructure) AND (defin* OR descry* OR category*) AND (cyclone OR flood OR hurricane OR storm OR tornado OR tsunami OR typhoon) AND disaster	123
Science Direct	(public health infrastructure OR public health OR Infrastructure) AND (defin* OR descr* OR category*) AND (cyclone OR flood OR hurricane OR storm OR tornado OR tsunami OR typhoon) AND disaster	1,124
Scopus	(public health infrastructure OR public health OR Infrastructure) AND (defin* OR descry* OR category*) AND (cyclone OR flood OR hurricane OR storm OR tornado OR tsunami OR typhoon) AND disaster	2,183
Wiley Online	(public health infrastructure OR public health OR Infrastructure) AND (defin* OR descry* OR category*) AND (cyclone OR flood OR hurricane OR storm OR tornado OR tsunami OR typhoon) AND disaster	401

Because this was a novel area of research, additional exclusions were required for some databases. The Medline search was limited to articles with abstracts and references, pharmacological actions, humans and core clinical journals. The CIHNAL, Scopus and Science Direct searches were limited to: Medicine; Nursing; Health Professions; Pharmacology, Toxicology and Pharmaceutics; Dentistry and Engineering. This approach ensured the search was tailored to each database, which increased the efficiency and accuracy.

Careful consideration was given to including Google Scholar. However, there are a range of concerns with its use. The retrieval and record management mechanisms are relatively unsophisticated and lack quality compared to other databases.[60,61] Results with Google Scholar are displayed in relation to times of visits from users, not in relation to quality of the publications.[62] Also, this research was focused on peer-reviewed literature, grey literature was excluded. For these reasons the Google Scholar was only used to explore reference lists and citations of relevant literature.

3.3.2.2.3 Selection strategy

The selection of articles occurred over three stages after retrieval from a database. This included a selection of articles based on the title, followed by an abstract review and then a full text analysis. An article was considered valid if the inclusion criteria was achieved, which included defining, describing or categorising PHI for humans and discussing how tropical cyclone, flood, storm, tornado, and tsunami related disasters impacted on PHI. Papers were excluded if they did not define, describe, or categorise PHI and discuss tropical cyclone, flood, storm, tornado and tsunami related disasters.

3.3.2.3 Data evaluation

The evaluation was conducted by organising the data, reading, memoing and data description.[23] The methodology for each was:

- Data organisation: After being sourced the data (papers) were saved electronically and, where appropriate, hard copies stored on file.

- Reading and memoing: The data were read and memoing conducted through a combination of electronic notes and by hand using a highlighter and pen. The information gathered was captured electronically (a table embedded in a Microsoft Word [Microsoft Corp, Redmond, WA, USA] Document) and coded according to key phrases, ideas and concepts.

- Data description: an individual description for each paper was developed. This included categorising the papers into six data types: opinion; description; literature review; qualitative; quantitative; and mixed methods. This was followed by describing each paper's key phrases, ideas, concepts and grouping PHI identified into themes.

3.3.2.4 Data analysis

The data was thematically analysed and then the degree of interdependency (or interdependency index) calculated.[63] The thematic analysis included a grouping of PHI themes identified and a description of key phrases, ideas and concepts for each theme. The degree of interdependency was then calculated to prioritise PHI based on its importance for maintaining health services for the community. This interdependency process was selected because it is validated tool that describes the relationship between two themes and the influences/correlation with the other.[63] In other words, two themes are interdependent when each is dependent on the other.[63]

The degree of interdependency was evaluated by values between 0 and 1 were used, where 0 represents the absence of interdependency, while 1 represents maximum interdependency between the two themes.[63] For example, a low independency was considered 0.3, medium 0.6, and high 1.0. [63,64] The use of the terms "low", "medium" and "high" was based on Pederson et al (2006)[64] and the 0.3, 0.6 and 1 scores used by Solari and Cineller (2013)[63].

To rank the interdependency, the scores for each PHI theme were added. The total score for a row reflected the leadership index and the column score was the subordination index. The theme with the highest leadership index was considered the most important because if its functionality fails, the performances of health services for the community decrease dramatically. The theme with the highest subordination index had the greatest dependency on

the other PHI within the community.[63] Both index scores for each theme were then added to provide the ranking.

The interdependency ranking process was conducted by four assessors: two clinicians (one with a humanitarian focus); an environmental health /disaster health professional; and a public health practitioner/academic. The assessors were selected to ensure the process was completed by an interdisciplinary team (clinical practice, disaster management, policy and research). The team members were chosen based on independent recommendations, respected knowledge and peer-reviewed publications. Each assessor individually completed the ranking process (matrix) by allocating the degree of interdependency for PHI themes (for example, how dependant is water on equipment) using 0 as no dependency, 0.3 low, 0.6 medium and 1 high. The scores by each assessor were aggregated and averaged to provide an overall prioritisation of PHI.

3.3.3 *Results*

3.3.3.1 Literature Search

The search strategy identified 4,932 potentially relevant articles. After applying the inclusion and exclusion criteria, 90 full text articles were analysed. Of these, 23 were rejected because they did not define, describe or categorise PHI and discuss cyclone, hurricane, typhoon, flood, storm, tornado and tsunami related disasters. The remaining 67 were identified as relevant and data extracted (Figure 3-4).

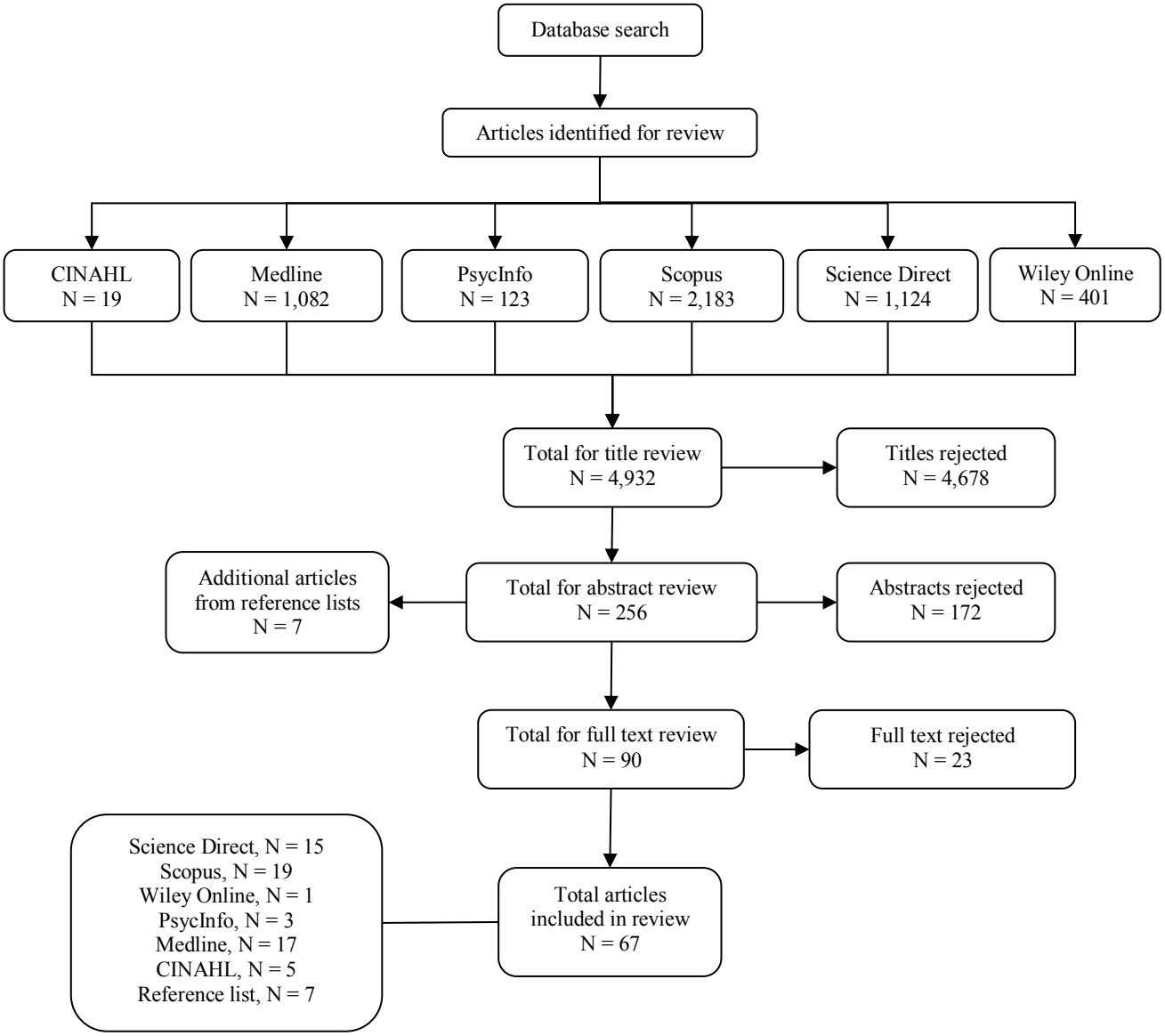

Figure 3-4 Literature review flow chart

3.3.3.2 Data Evaluation

A matrix was developed to provide an individual case description for each article (Table 3-7). The most common data type was an opinion article (n=22; 33%). This was followed by description (n=16; 24%), literature review (n=10; 15%), mixed methods (n=9; 13%), quantitative (n=7; 11%) and qualitative (n=3; 4%). Based on this, 57% of articles were opinion or description related and 28% scientific (mixed methods; quantitative and qualitative). The remaining 15% were literature reviews.

Table 3-7 Individual case description

Article	Data type	Description	Origin	Disaster
[63]	Literature review	Proposes a method of analysis for interdependency among community infrastructure.	Italy	General disaster
[65]	Description	Description of the impact Hurricane Sandy had on infrastructure and the costs.	USA	Hurricane Sandy
[66]	Opinion	Reviews the utility of social media for public health, with an emphasis on its application to disease surveillance.	UK	General disaster
[67]	Description	A description of community impacts, responses and public communication issues.	Japan	Japanese Tsunami
[68]	Literature review	Outlining information required to rapidly plan a disaster response, especially in sudden-onset disasters.	Australia	General disaster
[69]	Opinion	Hurricane Katrina lessons for medical planning, preparation, and response to disasters.	USA	Hurricane Katrina
[70]	Description	Describes the design and evaluation of the Wireless Internet Information System for Medical Response in Disasters.	USA	General disaster
[71]	Description	Delineate the impact of acute and chronic crises on cleft care.	USA	Hurricane Katrina
[72]	Mixed methods	Proposes a semi-quantitative risk assessment model for primary health care service interruption during flood.	Sudan	Flood general
[73]	Description	Describes health threats posed by disasters and actions to reduce morbidity and mortality.	USA	General disaster
[74]	Opinion	Outlines the need to understand the pharmaceuticals and medical equipment required for disasters.	USA	General disaster
[75]	Quantitative	Analyses the consequences of climate-change on critical infrastructure.	Spain	General disaster
[76]	Opinion	Outlines issues in US public health based on lessons from Hurricane Katrina.	USA	Hurricane Katrina
[77]	Description	Focus on prevention in the disaster setting.	USA	General disaster

[78]	Quantitative	Data collection is required from hospitals after a disaster and education about drowning must be improved.	USA	Hurricane Andrew
[79]	Mixed methods	Health system strengthening should contribute to disaster management.	UN	General disaster
[80]	Quantitative	Describes electronic health data use by the Department of Veterans Affairs (VA) in the month after Katrina.	USA	Hurricane Katrina
[81]	Opinion	Introduces German civil protection activities	Germany	General disaster
[82]	Literature review	Explores trends and the future of telehealth.	Australia	General disaster
[83]	Mixed methods	Define a set of minimum personal health information for first responders/receivers.	USA	General disaster
[84]	Literature review	Provides an evaluation model for preparedness of pharmaceutical services in disaster situations.	Brazil	General disaster
[85]	Quantitative	Baseline public health standards need to be met for non-flood periods to improve the response during floods.	India	Flooding, India
[86]	Qualitative	Public health and infection control nurses must partner and continue to address gaps in disaster planning.	USA	General disaster
[87]	Literature review	Presents concepts of disaster preparedness and response in health systems.	Switzerland	General disaster
[88]	Mixed methods	Defining public health functions in Australia.	Australia	General disaster
[89]	Description	Provides public health professionals with guidance on the management of disasters.	USA	General disaster
[90]	Opinion	Discusses how public health can contribute to making disaster management more effective.	USA	General disaster
[91]	Opinion	Discusses public health services in an emergency with a focus on Physician Assistants.	USA	General disaster
[92]	Literature review	Presents an impact analysis model to assess the uncertainties associated with workforce recovery.	USA	General disaster
[93]	Literature review	Explores the roles pharmacists assume in disasters.	USA	General disaster

[94]	Qualitative	A description of public health functions in the USA.	USA	General disaster
[95]	Opinion	Challenges for maintaining hospital nursing surge capacity.	USA	General Disaster
[96]	Qualitative	Barriers impeding rural physicians from being prepared for a human-induced disaster such as a bioterrorist attack	USA	General disaster
[97]	Description	Describing the public health impact of the Paris, France, floods in 1910.	France	Flooding, France
[38]	Description	Discusses the role of public health in reducing human vulnerability to climate change.	USA	General disaster
[98]	Description	Principles to guide emergency managers and others for effective disaster management.	USA	General disaster
[99]	Description	Described public health support provided to a mobile field hospital in Waveland, Mississippi	USA	Hurricane Katrina
[100]	Description	Reports on potential impact of extreme weather events on the management of healthcare facilities.	Australia	General disaster
[101]	Opinion	Proposes a framework to understand the medical system role in minimising the health impact on vulnerable populations.	USA	General disaster
[102]	Mixed methods	Information on the Public Health Functions	UN	General disaster
[103]	Opinion	Explores the association between health geography and public health.	UK	General disaster
[104]	Opinion	Discusses the field of public health and its role.	USA	General disaster
[105]	Quantitative	Outlines alternate-site medical surge capacity for safe and effective care for patients seeking urgent and emergent care.	USA	Hurricane Katrina
[106]	Opinion	Explores approaches to disaster preparedness.	Israel	General disaster
[107]	Opinion	Introduces how public health integrates into disaster preparedness and response.	USA	General disaster

[108]	Mixed methods	Post disaster mental health services should remain available for years post-event.	USA	Hurricane Katrina
[109]	Mixed methods	Describes formation of a community and university partnership to make changes after Hurricane Floyd.	USA	Hurricane Floyd
[110]	Literature review	Explores the relevance of resilience for disaster planning and public health protection.	UK	General disaster
[111]	Opinion	Explores the interplay of mitigation, insurance, engineering, building codes and policy-making after hurricanes.	USA	Hurricane Katrina
[65]	Opinion	Assess potential construction and maintenance costs of different flood management strategies.	USA	Hurricane Sandy
[112]	Literature review	Analyses information on deaths from the Queensland 2010-11 floods with previous floods in modern Australia.	Australia	Flooding, Australia
[113]	Description	Describes the role of hospitals in a disaster and challenges faced.	USA	Hurricane Katrina
[114]	Opinion	Discusses mapping across England for future hazards, vulnerability and risk.	UK	General disaster
[115]	Description	Long-term need for medical and mental health services after a disaster.	USA	Hurricane Katrina
[116]	Mixed methods	Investigated the practices that comprise of sheltering school-aged children residing in areas impacted by natural disasters.	USA	Hurricane Katrina
[117]	Quantitative	Identifies planning that impacts hospital management of evacuations and challenges faced when sheltering-in-place.	USA	Hurricane Rita
[9]	Opinion	Outlines minimum standards for a Humanitarian Response	USA	General disaster
[118]	Opinion	Discusses the response to Hurricane Katrina.	USA	Hurricane Katrina
[119]	Opinion	Disaster frameworks be reformed to emphasize and clarify the relationship between public health emergencies and modern disasters.	USA	General disaster
[120]	Opinion	Considerations for developing community disaster mitigation strategies.	USA	General disaster

[121]	Quantitative	Quantifying tangible and intangible flood damage according to monetary values and the number of people affected.	Netherlands	Flood general
[122]	Mixed methods	Investigates relationships between self-interest, economic and political conditions, and public opinion on health for vulnerable populations.	USA	General disaster
[123]	Description	Overview of how commissioned nurses respond to disasters.	USA	General disaster
[124]	Opinion	The recent hurricanes in the Gulf of Mexico exposed the poverty of US public health infrastructure	USA	Hurricane's Katrina and Rita
[125]	Literature review	Explores civil infrastructure resilience, particularly water distribution systems.	USA	General disaster
[126]	Opinion	Conceptual framework for surge capacity	USA	General disaster
[127]	Description	Chronicles the displacement of Psychiatry services and barriers for returning health care providers to their communities.	USA	Hurricane Katrina

Of the 67 articles, 19 (28%) focused on hurricane, five floods (8%), one tsunami (1.5%) and the remaining 42 (63%) on more than one disaster type: tropical cyclone, flood, storm, tornado and tsunami (Figure 3-5). The most common disaster discussed was Hurricane Katrina (n=13) followed by Hurricane's Sandy (n=2), Rita (n=1), Andrew (n=1) and Floyd (n=1). One article discussed both Hurricane Katrina and Rita. The articles also discussed flooding in Paris, France, in 1910 (n=1); Brisbane, Australia, in 2011 (n=1); Orissa, India, in 2008 (n=1); and the Japanese tsunami in 2011 (n=1). The remaining articles (n=45) focused more broadly on tropical cyclone, flood, storm, tornado, and tsunami related disasters.

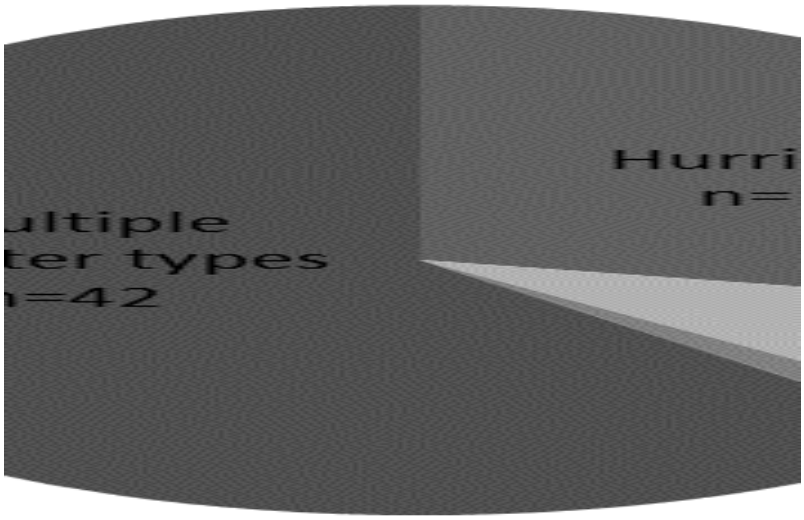

Figure 3-5 Articles by disaster type

The majority of articles (n=44, 66%) originated from the United States of America (USA) (Figure 3-6). The next most common origin was Australia (n=6, 13%) followed by the United Kingdom and other entities including the United Nations (UN) (n=3, 4%). The other origins of the papers were Brazil, Germany, France, India, Israel, Italy, Japan, Netherlands, Spain and Switzerland (n=1).

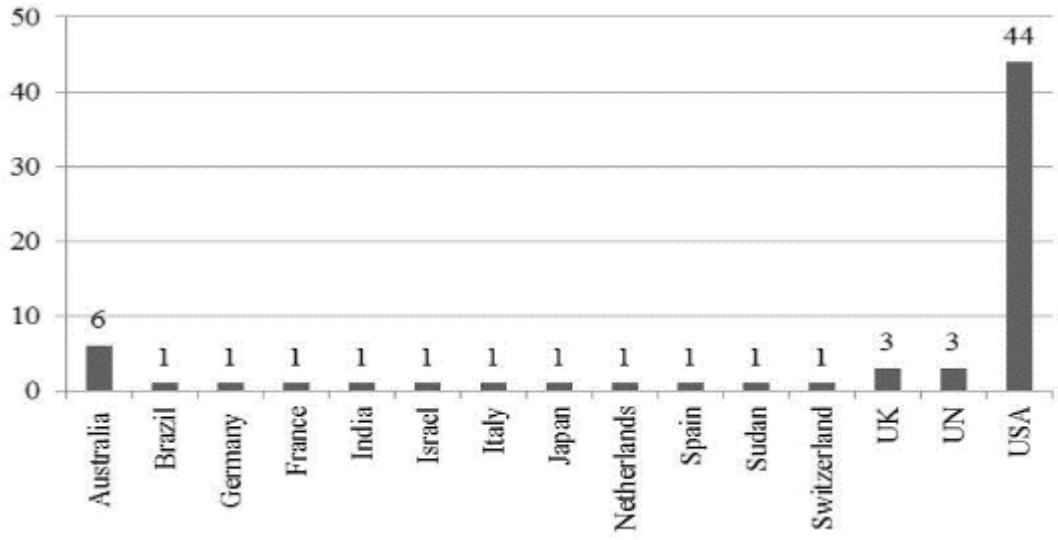

Figure 3-6 Articles by origin

3.3.3.3 Data Analysis – Thematic

There were 158 different descriptions of PHI, which were grouped into 13 themes (Table 3-8). These included: communication; equipment; governance; physical structure; power; prevention; sanitation; services; supplies; surveillance; transport; water; and workforce.

Table 3-8 Public health infrastructure themes and description for disasters

Theme	Description	References
Communication	Broadband; communication; cameras; electronic records; information sharing; information systems; information technologies; internet; media relations; mobile communication; referral system; satellite communication; signs; social media; technology; telecommunication; telephone; traffic lights. (n=18)	[63,66,67,69-90,92,128] (n=27)
Equipment	Beds; equipment; hand washing facilities; hospital beds; medical devices; refrigeration; sharps; water closets; water pumps. (n=9)	[38,69,72-74,88,95-101] (n=13)
Governance	Agreements; business continuity; command and control; coordination; disaster system; emergency management committee; financial; funding; government; hospital system; interagency coordination; law enforcement; leadership; governance; legal administration. (n=14)	[38,63,69,71,72,75,84-86,91,95,102,103,105-108,110] (n=18)
Physical structure	Buildings; community infrastructure; food storage; health facilities; healthcare; homes; hospital; hospital infrastructure; housing; medical facilities; medical infrastructure; physical infrastructure; primary care offices; shelter; storage facilities; structures. (n=16)	[38,63,67-69,71,72,74,79,81,84,85,87-89,96,98,100,101,105,108,110-120,128] (n=34)
Power	Electricity; energy; energy supply; generators; power; power plants; power supply; power lines. (n=8)	[63,65,69,72,73,75,81,85,89,90,92,97,98,100,107,113,114,117,120-122,128] (n=21)
Prevention	Prevention; promotion; public health prevention; research. (n=4)	[38,86,88,94,102,103] (n=6)

Sanitation	Drainage; hygiene; infection control; latrines; medical waste; plumbing; sanitation; sewage systems; solid-waste collection; waste disposal; waste management; wastewater; water disinfection; water treatment. (n=14)	[9,38,63,65,73,79,85,87,89,99,102-4,106,107,110,113,114,119,124] (n=20)
Service	Acute medical care; ambulance; business; clinics; communicable disease control; diagnosis; disinfection; education; emergency departments; emergency medical services; environmental health; epidemiology; filtration; food safety; health promotion; healthcare program; healthcare providers; laboratory services; medical care; medical practices; medical services; mental health; military; nursing homes; nursing services; public health surveillance; outpatient clinics; pharmacies; social service; supporting systems; surveillance; utilities; vaccine programs; welfare. (n=34)	[9,38,63,72,77-80,86,89-91,93,94,96,98-110,115,118-120,122,123,125] (n=35)
Supplies	Food; food supplies; food sources; fuel; gas; medical products; medications; medicine; mineral oil; natural gas; pharmaceutical supplies; prescription drugs; supplies; supply networks; vaccinations; water sources. (n=16)	[9,38,63,66,69,73-75,81,85,87,89-91,93,95-98,100,103-106,109,113,114,118-120,122-124,126-128] (n=37)
Surveillance	Assessments; health data; health information; monitor; mortality information; public health assessments. (n=6)	[9,66,68,77-79,83,94,119,123](n=10)
Transport	Airport; bridges; footpath access; mobilization; road network; roads; subways; transport; transportation. (n=9)	[63,65,67,72,75,85,89,91,92,100,105,106,109,110,112,114,116,117,128] (n=22)
Water	Dams; drinking water; water; water supply (n=4)	[9,38,63,66,69,72-75,79,81,85,86,89,91,97,100,103,105,107,112-114,117-120,122,124,125] (n=30)
Workforce	Care coordinator; carers; emergency response trauma teams; epidemiologists; health professionals; jobs; nurses; personnel; pharmacist; public health officials; public health personnel; social professionals; staff; trained staff; workforce. (n=15)	[69,72,78-80,85,88-90,92,93,95,96,98,107,109,113-115,117-119,126] (n=23)

Each of the themes had varying descriptions and citations. The theme with the greatest number of descriptions was services (n=34) followed by communication (n=18) and workforce (n=15). The themes with the most citations were services (n=35) followed by physical structure (n=34). A description of the themes follows.

3.3.3.3.1 Communication

Communication included: internet and intranet systems; telephony (telephone and mobile communication); media; and, more generally, technologies used to communicate.[63,66-90,128] Communication also referred to traffic cameras, signs and traffic lights.[85,91,92] In a disaster situation, internet and intranet systems allow access, monitoring and transmission of information required to prepare and respond to a disaster.[70,80,82,88,93,94] Telephony allows people to verbally discuss and share information.[63,68,88,90] Media was identified as a mechanism for communicating on social networks, radio, television and other means used to share information.[66]

3.3.3.3.2 Equipment

Equipment was categorised into: clinical; hygiene (hand washing facilities and water closets); refrigeration; and water pumps.[38,72-74,88,95-102] Clinical equipment was considered items used to treat patients (for example, beds, medical devices and disposable items).[98,101] Hygiene included practices used for infection control and refrigeration ensured medicines and food were stored at appropriate temperatures.[38,86,99,100,103,104] Water pumps were identified as having a range of uses and required to ensure water can be transported (for example, from a rainwater tank to the tap).[38,72] More generally, equipment was found to allow patients to be treated and ensure hygiene standards were maintained.[96,98,99,102]

3.3.3.3.3 Governance

Governance was described as: agreements; command; control and coordination (leadership); planning (business continuity and policy); disaster system; finance and funding; and laws (enforcement and administration).[63,75,76,84-86,88,91,93,98,102,103,105-111] Agreements referred to arrangements and partnerships in-place between agencies and organisations to prepare and respond to a disaster.[86,106] Command, control and coordination was described as the systems and processes used to prevent duplication of activities and enhance efficiency of available

resources (for example, military support).[76,84,88,91,103,105-107] Planning referred to preparations undertaken for disasters, including elements of the disaster system (for example, emergency management committee) and policy development.[80,86,93,102,106,108,111] Finance and funding referred to commodities and accessing funds required to ensure appropriate activities before, during and after a disaster.[63,75,85] Laws were described as the legislative frameworks to protect and gather information, enforce standards, maintain hospital safety and ensure accurate record keeping.[71,84,85,94,102,103,107,110]

3.3.3.3.4 Physical structure

Physical structure was categorised as: buildings; storage facilities; health facilities; shelters; and general infrastructure.[9,38,63,68,69,72,81,84,85,88,89,96,100,101,103,105,108,110-117,128] Buildings included accommodation and more generally shelters used to protect people from the elements.[68,110,112] Storage facilities included sites used to house goods, supplies and equipment.[87,100] Health facilities referred to those aspects of buildings used for delivering health services (for example, hospitals, medical facilities and primary care offices).[38,68,69,72,81,84,85,88,89,98,100,101,108,111] Shelter included housing and homes, which can be temporary (such as schools) or permanent structures (such as houses).[38,67-69,74,79,89,90,114,115,118] Shelter provided a mechanism for people to stay safe and healthy.[69,94,103,118,119] It was also identified as being particularly import for vulnerable populations.[38,69,74,79,119] Finally, the impact of a disaster on physical structures included a loss of hospital style care and basic services for treating patients and maintaining community wellbeing.[38,69,85,96,101,108,115]

3.3.3.3.5 Power

The descriptions of power included: electricity; power lines; and energy supply (generators and power plants).[38,63,69,72,75,81,85,89-92,100,107,113,114,117,120-122,128] Electricity was identified as being used to power lights, medical devices and water treatment plants.[63,73,85,89,103,114,117,128] Power lines were identified as the infrastructure used to transfer electricity, and energy supply referred to items used to generate power.[81,90,92] It was identified that without power the services and equipment required to provide health care was limited.[9,89,91,114,122] This was due to the heavy reliance of medical devices on power.[73,85,91,113,114] Communication, sanitation systems, food safety and water supply infrastructure were also identified as dependent on power.[9,63,72,73,75,85,100,103,107,114,123]

3.3.3.3.6 Prevention

Prevention was described as: health promotion; research; and public health programs.[38,88,94,102,103,108] Health promotion incorporates activities focused on encouraging the community to maintain healthy lifestyles and promote strategies to avoid contracting communicable diseases.[63,86,94,102-104] Research ensured strategies implemented were based on evidence.[88,94,102,103] Public health programs included governance and legal means to protect the health and wellbeing of individuals and the community.[94,103,108]

3.3.3.3.7 Sanitation

Sanitation included: drainage (plumbing); hygiene (infection control); sewage (latrines); solid-waste management; general waste management (medical and non-medical); and water treatment.[9,38,73,79,85-87,89,99,100,102-104,106,107,110,113,114,119,124,128] Drainage referred to mechanisms for removing water and other waste products.[87,103,113] Hygiene was identified as the processes in-place to prevent disease outbreaks (for example, hand washing and sanitization of equipment).[102,104,107] Sewage was described as the systems used to separate contaminants and waste treatment.[38,63,73,89,100,103,107] Waste management referred to the systems used to manage refuse from households, hospitals and the general community.[85,99,103] Water treatment and disinfection included treating water to ensure it was free from contaminations and microorganisms.[85,99,106,114,118,128]

3.3.3.3.8 Services

The descriptions for services included: business; hygiene (disinfection and filtration); medical (clinics, pharmacies and utilities); public health; military; and social.[9,38,63,72,77-80,85,86,90,91,93,94,96,99-110,115,119,120,122,123,125] Business referred to the functionality of health companies including food businesses.[63,109] Hygiene was the need to prevent infection and spread of disease.[38,100,105,106] Medical was the provision of medical services and treatment (for example, hospital care, immunization programs and outpatient services).[38,78-80,85,89-91,103,104,106,110,119,122] Public health was closely linked with prevention and focused on intervening/preventing disease at a community level.[93,101] The military referred to emergency health services provided by a nation's armed forces.[63,91,107] Social was identified as psychological care and services provided outside a medical facility.[109,125]

3.3.3.3.9 Supplies

Descriptors for supplies were grouped into: fuel (gas and oil); medical products (medicines, pharmaceuticals and vaccinations); food; supply networks; and water sources.[38,63,69,74,75,79,81,85,87,89,93,95,96,98,100,101,104,114,119,120,122,126,127] Fuel was described as being used to generate power for houses, business, water treatment, sewage systems and vehicles.[38,63,65,68,69,81,89,100,106,107,113,114,119] Medical products were used to treat existing and acute conditions, including the delivery of immunization programs.[79,85,93,95,127] Food related to agricultural crops and the supply of nutritious meals.[9,38,63,66,73,74,89-91,103,105,109,114,118-120,122-124] Nutritious food was also identified as important to ensure people can stay healthy and have the energy required to respond to a disaster.[9,79,119,122] Supply networks were identified as mechanisms to distribute supplies through communication and transport.[126] Water sources provided drinking water and hygiene capabilities.[38,73]

3.3.3.3.10 Surveillance

Surveillance included: assessment; monitoring; gathering health data; and health information systems.[9,66,68,77,78,80,83,89,94,103,107,119] Assessment referred to epidemiology and statistical analysis of data.[68,77,89] Monitoring included public health assessments to gather information and inform response and recovery operations.[9,80] Health data was used understand the situation, including monitoring disease trends.[66,78,89,94,102,123] Health information incorporated mortality, morbidity and general information relating to health services. This infrastructure informed early detection of disease outbreaks, provided an understanding of disaster impacts and a mechanism for evaluating interventions.[77-79,103,107,119]

3.3.3.3.11 Transport

Transport was categorised as: airports; bridges; logistics; mobilisation; public transport (subways); roads; and transportation.[63,67,68,75,81,85,89-91,100,105,106,109,110,112,114,116,117] Airports were used for planes and helicopters, which provided a vital means for transporting patients. Bridges were identified as a key part of transport infrastructure along with roads.[67,85,90,92,100,110,112,128] This included highways, state roads and local roads. If damaged, transport, logistic and mobilisation options for patients, the community and disaster management systems are

affected. [72,103,116] Public transport included subways, buses, trams and footpaths.[114,128] This infrastructure provided mass transit options for the community and was identified as vital before and after a disaster. Generally, it included ambulances, cars and motorcycles.[118]

3.3.3.3.12 Water

Water was described as: water storage; drinking water; and water supply.[9,38,63,69,72-74,81,85,86,89,91,100,103,105,107,112-114,117-120,122,125] Water storage referred to a community, farm or household (rainwater tank) storage. [112,114] Drinking water was used for food preparation, hydration, hygiene and medical treatment.[9,38,66,73,79,85,86,89,100,107,114,118,119,122] Water supply referred to reticulation systems and storage.[63,69,72,81,85,97] Without water, hydration cannot occur and the capability for effective hygiene practices would be limited.[38,107] Also, this prevented sanitation systems from effectively working along with medical treatments such as dialysis.[86,100,107,119,124]

3.3.3.3.13 Workforce

Workforce was described as: carers; public health professionals; medical professionals; social professionals; and staff.[72,78-80,85,88-90,92,93,95,96,98,107,109,113-115,117,118,126] A carer looks after the elderly and family members who are unwell or disabled.[80,114] Public health professionals work at the population level and included environmental health professionals, epidemiologists, public health officials and health promotion officers.[77,78,89,90,93,102,107,115,119] Medical professionals were identified as providing individual ongoing acute treatment and included doctors and nurses.[98,103,114,115,118] Social professionals provided mental health and other support activities for those in need. [98,114,115] If the workforce is disrupted, the quality and safety of health care services for patients and the broader community was found to be negatively impacted.[69]

3.3.3.4 Data Analysis – Degree of Interdependency

The four assessors conducted an evaluation of each theme and the scores averaged (Table 3-9). Workforce was identified as the most important. It was the highest ranked on the leadership index (9.4) and has the greatest dependency on other PHI (9.7). The next five highest themes on the leadership index were physical structure, sanitation and water (7.9), communication (7.8) and equipment (7.4). The five themes after the workforce with the greatest dependency on others were equipment (8.6), water (8.4), sanitation (8.1), communication (7.6) and prevention (7.5).

Table 3-9 Public health infrastructure interdependency matrix for disasters

	Rating of dependency after a disaster													
Public health infrastructure (theme)	**Communication**	**Equipment**	**Govt and info**	**Physical structure**	**Power**	**Prevention**	**Sanitation**	**Service**	**Supplies**	**Surveillance**	**Transport**	**Water**	**Workforce**	**Leadership index**
Communication	1.0	0.8	0.5	0.9	0.8	0.7	0.2	0.4	0.5	0.4	0.2	0.8	0.7	**7.8**
Equipment	0.6	1.0	0.5	0.6	0.7	0.2	0.6	0.3	0.8	0.2	0.7	0.6	0.6	**7.4**
Governance	0.7	0.4	1.0	0.5	0.4	0.6	0.4	0.6	0.4	0.4	0.4	0.5	0.8	**6.9**
Physical structure	0.8	0.7	0.4	1.0	0.7	0.5	0.7	0.5	0.5	0.2	0.5	0.7	0.6	**7.9**
Power	0.6	0.8	0.6	0.4	1.0	0.3	0.6	0.4	0.4	0.3	0.5	0.6	0.7	**7.0**
Prevention	0.5	0.3	0.5	0.2	0.2	1.0	0.9	0.3	0.3	0.7	0.2	0.6	0.7	**6.3**
Sanitation	0.3	1.0	0.4	0.9	0.6	0.7	1.0	0.5	0.3	0.3	0.2	1.0	0.7	**7.9**
Service	0.6	0.5	0.6	0.3	0.5	0.4	0.7	1.0	0.4	0.4	0.6	0.5	0.8	**7.2**
Supplies	0.4	0.7	0.5	0.5	0.4	0.5	0.5	0.5	1.0	0.4	0.7	0.7	0.6	**7.1**
Surveillance	0.6	0.3	0.6	0.2	0.2	0.9	0.6	0.3	0.2	1.0	0.4	0.4	1.0	**6.6**
Transport	0.4	0.6	0.5	0.6	0.2	0.3	0.4	0.5	0.7	0.2	1.0	0.5	0.8	**6.5**
Water	0.4	0.9	0.4	0.7	0.6	0.7	0.8	0.4	0.6	0.4	0.4	1.0	0.7	**7.9**
Workforce	0.7	0.5	0.7	0.5	0.7	0.8	0.9	0.8	0.6	0.8	0.7	0.7	1.0	**9.4**
Subordination index	**7.6**	**8.5**	**7.0**	**7.2**	**6.9**	**7.5**	**8.1**	**6.3**	**6.5**	**5.6**	**6.5**	**8.4**	**9.7**	**---**

An aggregation of the leadership and subordination index scores provided a raking for PHI (Table 3-10). Based on this, PHI priorities were identified as: 1 workforce, 2 water, 3 sanitation, 4 equipment, 5 communication, 6 physical structure, 7 power, 8 governance, 9 prevention, 10 supplies, 11 service, 12 transport and 13 surveillance.

Table 3-10 Ranking and categorisation of public health infrastructure in a disaster

Public health infrastructure by priority	**Leadership index (ranking)**	**Subordination index (ranking)**	**Combined score**
1. Workforce	9.6 (1)	9.7 (1)	19.2
2. Water	7.9 (2)	8.4 (3)	16.3
3. Sanitation	7.9 (2)	8.1 (4)	16.0
4. Equipment	7.4 (6)	8.6 (2)	16.0
5. Communication	7.8 (5)	7.6 (5)	15.4
6. Physical structure	7.9 (2)	7.2 (7)	15.0
7. Power	7.0 (9)	6.9 (9)	13.9
8. Governance	6.9 (10)	7.0 (8)	13.9
9. Prevention	6.3 (13)	7.5 (6)	13.7
10. Supplies	7.1 (8)	6.5 (10)	13.6
11. Services	7.2 (7)	6.3 (12)	13.5
12. Transport	6.5 (12)	6.5 (11)	13.0
13. Surveillance	6.6 (11)	5.6 (13)	12.2

3.3.4 *Discussion*

Workforce can be considered the most important of the 13 thematic areas related to PHI and disasters PHI. If its functionality fails, it has the greatest impact on the performance of health services and is highly dependent on the other PHI. If workforce issues are overcome post disaster the remaining 12 forms of PHI will then be progressively addressed. The next priority PHI is water followed by sanitation, equipment, communication, physical structure, power, governance, prevention, supplies, service, transport and surveillance. Based on this description,

PHI should be defined as "the workforce, equipment, supplies and services required to maintain the health and wellbeing of individuals and the community".

The ranking of communication (number 5) reflects the rapid progress in telecommunication technology. Communication no longer needs to be a major limiting factor before, during and after a disaster. For example, in the 1990s and before, a lack of communication was considered the paralysing factor in 80% or more of disaster scenarios.[129] This shift highlights the need to tailor disaster activities to reflect modern day priorities.

An interesting finding was surveillance being ranked as number 13. Surveillance is an important aspect of the health system. However, this ranking reflects that the functionality will be regained once the other PHI is addressed after a disaster. It is important that all themes identified are required to maintain the health and wellbeing of individuals and the community.

The application of the interdependency method used by Solari and Cimellaro (2013) allowed the relationship between two forms of PHI and the influences/correlation with the other to be explored.[63] Although the degree of interdependency measurement used (low is 0.3, medium 0.6 and high 1.0) is subjective, it provides a framework for systematically ranking and prioritising PHI.

The findings support the mainstreaming of health into the *Sendai Framework for Disaster Risk Reduction 2015-2030* (Sendai Framework).[130] PHI is linked to all the disaster risk reduction priority actions. The rankings of PHI presented could be used as a guide to progressively increase resilience, particularly for at-risk populations. This could potentially result in an expansion from the traditional disaster approaches (physical capacity and material disaster relief) to a focus more on community resilience through PHI.[131]

Overall, this research will help disaster management and health systems prepare, respond and recover from the PHI aspects of disasters. Ensuring the workforce is available should be the first priority for disaster and health planners. This could include providing an emergency child minding service to facilitate the return to work of health care staff.[132] Once planning and preparations for workforce issues are addressed the next focus should be maintaining water followed by the remaining PHI in order of priority. Ultimately, this provides a platform to help disaster preparation, response and recovery encompass the entire PHI spectrum.

3.3.5 *Limitations*

The research was influenced by the lead author's studies and work in public health and disaster management in Australia at local, state and national levels and across the Asia-Pacific. To address this, the themes identified were checked by the second author and the results reviewed by all authors.

A potential limitation is that all the disasters and events of interest may not have been in the literature available for review. This is a limitation for studies such as this which are focused on peer-reviewed literature. However, the research still provides a basis to start the discussion about PHI priorities before, during and after a disaster.

The interdependency ranking process for the PHI themes is also a limitation. To minimise the impact of this limitation, the interdependency ranking was completed by the first four authors. This included two clinicians (one with a humanitarian focus); an environmental health/disaster health professional; and a public health practitioner/academic. The scores by each assessor were then aggregated and averaged to provide a prioritisation of PHI. The results may still be relevant to other disaster health audiences; however, the next step should be a process of validation. This should include a broader cohort of disaster responders, health professionals, government officials and community representatives ranking and prioritising PHI.

Another potential limitation is transferability of the findings outside high-income country settings. The review and subsequent analysis was limited to articles that predominately originated from high-income countries (USA, Australia and UK). Caution should be taken in applying the results to low and middle-income countries as the PHI priorities may change.

3.3.6 *Conclusions*

The workforce was identified as the most important of the 13-thematical areas related to PHI and disasters. If its functionality fails, it has the greatest impact on the performance of health services and is highly dependent on the other PHI. If workforce issues are overcome post disaster the remaining 12 forms of PHI will then be progressively addressed. The next priority PHI is water followed by sanitation, equipment, communication, physical structure, power, governance, prevention, supplies, service, transport and surveillance. The research also

supports the mainstreaming of health into the Sendai Framework. PHI is linked to all the disaster risk reduction priority actions. Overall, the findings presented are a step towards providing an evidence base to inform PHI priorities in the disaster setting.

3.4 Identifying the impact of disasters on noncommunicable diseases

Published – Ryan BJ, Franklin RC, Burkle FM, Aitken P, Smith EC, Watt K and Leggat P (2015). Identifying and Describing the Impact of Cyclone, Storm and Flood Related Disasters on Treatment Management, Care and Exacerbations of Non-Communicable Diseases and the Implications for Public Health. PLOS Currents: Disasters. 2015(7). Impact factor not available; Indexing PubMed and Scopus; Google Scholar citations 14 – Appendix C.

3.4.1 *Introduction*

Over the past quarter of century there has been a global increase in the frequency and severity of disasters and burden of noncommunicable diseases (NCD).[4,133] For example, since 2005 disasters have resulted in over 700 thousand deaths, over 1.4 million people being injured, approximately 23 million people homeless, 1.5 billion people affected and economic losses of more than $1.3 trillion.[130] Of the disasters worldwide cyclone, flood and storms have accounted for 88% and are responsible for 76% of disaster related deaths.[6,48] This threat is anticipated to continue, if not increase, with climate change expected to make extreme weather events more frequent and severe.[15,16,130] For individuals with NCDs this represents a significant risk because disasters jeopardise access to and often availability of public health treatment options, equipment, clean water and food, which can result in an exacerbation of existing conditions or even preventable death.[3,20,49,133-137]

This problem has been recognised globally by the United Nations in the *Sendai Framework for Disaster Risk Reduction 2015-2030* (Sendai Framework). Item 30(k) relates to chronic diseases (interchangeable with NCDs) and requests that due to their particular needs should be included in the design of policies and plans to manage risks before, during and after disasters, including having access to life-saving services.[130] This call to action builds on and compliments the

World Health Organization (WHO) *Global Action Plan for the Prevention and Control of Noncommunicable Diseases – 2013-2020* (WHO Action Plan).[12]

NCDs are prolonged illnesses, rarely cured completely and are not passed from person to person.[138, 139] There are four major groupings: cardiovascular diseases; cancers; chronic respiratory diseases; and diabetes.[140-142] These conditions account for 79% of NCD deaths globally and have common behavioural risk factors (smoking, physical inactivity, poor nutrition and harmful use of alcohol).[140,142,143] Minor groupings within NCDs include arthritis, obesity, mental health and renal conditions.[140,144-146]

The risk disasters pose to people with NCDs is further highlighted by the traditional public health focus on communicable diseases following a disaster when the actual risk is low (particularly in developed countries).[8] Improvements in life expectancy along with changes in lifestyle and diet have contributed to a "disease transition" from communicable diseases to NCDs.[9,133,143,147] NCDs are costly and time exhaustive to treat, which has implications for health systems' capacity and capability.[10,11] This impact is expected to rise over the coming decades as the prevalence of NCDs across the world increases, public health infrastructure is further compromised and economic pressures are placed on health systems.[138,139, 144,148]

To properly address and define the risk disasters pose to people with NCDs, public health focus of disaster management should be expanded to include the management of people with NCDs. To better identify the much needed administrative and operational platform for this to occur, a systematic review of the literature identifying and describing the impact of cyclone, flood and storm related disasters on people with the four major NCDs was completed. The NCDs included: cardiovascular diseases (heart attacks and stroke), cancers, chronic respiratory diseases (chronic obstructed pulmonary disease and asthma) and diabetes.[139,140,142]

A focus on cyclone, flood and storms is required to ensure the research reflects the natural disasters that are the most frequent and deadly across the world.[6,48] The objectives of this research were to: determine and describe the impact on the treatment management, exacerbation of and direct care for those with NCDs; and identify the impact on the health of the at-risk population with chronic NCDs. The findings presented will help public health disaster planners and professionals understand the impact of disasters on this most vulnerable population and the impact on both direct and indirect health consequences.

3.4.2 *Methodology*

An integrative review methodology was selected to systematically review literature due to its effectiveness in defining new concepts and direct applicability to practice and policy.[54,55] This methodology also allows specific aspects of previous research to be critically and methodically evaluated.[56] The PRISMA checklist guided presentation of the research (Table 3-11).[149]

Table 3-11 PRISMA checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	139, 143
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	139, 143
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	139, 144
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	144
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	145
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	144, 145
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	145

Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	145
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	145
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	145, 146
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	145, 146
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	142, 151
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	146
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	146
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	143-146
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	146, 147

Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	147
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	147
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	147 to 152
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	147
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	147 to 152
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	161, 162
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	163, 164
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	164
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	164

Consistent with an integrative review methodology the research was conducted over the stages of problem identification; literature search; data evaluation; and data analysis.[54] The problem identification phase was incorporated into the introduction section of this paper. An overview of the remaining three stages is provided in the following.

3.4.2.1 Literature search

The literature search included three components. The first was determining the search terms, second searching databases and third applying the inclusion/exclusion criteria.

The search terms were determined through a process of testing, refining and finalising in Medline between November and December 2014. The Medline database was selected because it is a useful tool for biomedical and allied health researchers and practitioners conducting literature searches.[57,58]

The search terms selected were: “cyclone”, “storm” or “flood”; and “disaster”; and variations for “noncommunicable disease”, “cancer”, “cardiovascular disease”, “chronic respiratory disease” or “diabetes”. The variations included were based on World Health Organization (WHO) NCD terms and include:

- Noncommunicable disease: “NCD” or “chronic disease”.
- Cancer: “malignant tumours” or “neoplasms”.[150]
- Cardiovascular disease: “coronary heart disease”, “cerebrovascular disease”, “peripheral arterial disease”, “rheumatic heart disease”, “congenital heart disease”, “deep vein thrombosis” or “pulmonary embolism”.[142]
- Chronic respiratory diseases: “asthma”, “chronic obstructive pulmonary disease”, “COPD”, “occupational lung diseases”, “lung disease” or “pulmonary hypertension”.[151]
- Diabetes: no variations, this term is specific for a condition where the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produce.[152]

To further maximise the search, variations of NCD terms those identified by WHO were used and included: "COPD" and "respiratory disease" for chronic obstructive pulmonary disease; "lung disease" for occupational lung diseases; and "heart disease" for coronary, rheumatic and congenital heart disease. Other terms such as obesity, chronic pain and alcohol related disorders were considered, however, they were not identified as NCDs by WHO. Based on this, the final search terms used were:

> *(Cyclone OR storm OR flood) AND ((noncommunicable disease OR NCD OR chronic disease) OR (cancer OR malignant tumours OR neoplasms) OR (cardiovascular disease OR coronary heart disease OR cerebrovascular disease OR peripheral arterial disease OR rheumatic heart disease OR congenital heart disease OR deep vein thrombosis OR pulmonary embolism) OR (chronic respiratory diseases OR asthma OR chronic obstructive pulmonary disease OR COPD OR occupational lung diseases OR lung disease OR pulmonary hypertension) OR (Diabetes) AND (disaster).*

3.4.2.1.1 Databases

A search of CINAHL, Medline, PsycINFO, Science Direct and Scopus databases was conducted in January 2015 with a date limit of 31 December 2014. These databases were selected to maximise the literature searched and minimise the risk of missing relevant articles. To further maximise the scope of the literature examined, reference lists of obtained literature were reviewed. Google Scholar was considered as one of the databases, however, the publications are not listed in relation to quality, they are displayed in relation to visits.[62] Also, the retrieval and record management mechanisms lack quality when compared to other databases.[60,61] For these reasons, Google Scholar was only used to explore reference lists and citations of obtained literature.

The search strategies differed based on the database functionality (Table 3-12). The Medline search was limited to articles with abstracts and references, pharmacological actions, humans and core clinical journals; Science Direct to health, patient, public health, disaster, emergency and medical; and Scopus to nursing, health professions, pharmacology, toxicology and pharmaceutics. No limitations were applied to CINAHL and PsycINFO. This approach combined with the searches of reference lists and citations in Google Scholar was designed to increase accuracy and ensure the search was tailored to each database.

Table 3-12 Search strategy

Search terms	Database	Limitations	Articles for review
(Cyclone OR flood OR storm) AND ((noncommunicable disease OR NCD OR chronic disease) OR (cancer OR malignant tumours OR neoplasms) OR (cardiovascular disease OR coronary heart disease OR cerebrovascular disease OR peripheral arterial disease OR rheumatic heart disease OR congenital heart disease OR deep vein thrombosis OR pulmonary embolism) OR (chronic respiratory diseases OR asthma OR chronic obstructive pulmonary disease OR COPD OR occupational lung disease OR lung disease OR pulmonary hypertension) OR (Diabetes)) AND (disaster)	CINAHL	Nil	11
	Medline	Articles with abstracts; articles with references; pharmacological actions; humans and core clinical journals	315
	PsycInfo	Nil	14
	Science Direct	Health; patient; public health; disaster; emergency; medical	467
	Scopus	Medicine; nursing; health professions; pharmacology, toxicology and pharmaceutics	1,581

3.4.2.2 Inclusion/exclusion criteria

An article was considered valid if the inclusion criteria was achieved, this included: discussing how cyclone, flood or storm related disasters impacted people with NCDs. Papers were selected from peer-reviewed journal articles which were either descriptive (described a situation or a specific disaster), mixed methods, qualitative or quantitative in their methodology. Papers were excluded if they did not focus on NCDs and discussed cyclone, flood or storm related disasters. Conference abstracts and literature reviews were excluded. The primary data sources from literature reviews were reviewed.

3.4.2.3 Data evaluation

The evaluation was conducted following the principles of qualitative research and included organising the data, reading and memoing and data description.[23,153,154] The method for each is:

- Data organisation: After being sourced the data (papers) were saved electronically and, where appropriate, hard copies stored on file.[23]

- Reading and memoing: The process was conducted through a combination of electronic notes and by hand using a highlighter and pen.[23,153,154] The information gathered was captured electronically (a table embedded in a Microsoft Word ™ Document) and coded according to key phrases, ideas and concepts.[23,153,154]

- Data description: an individual description was developed for each paper. This included categorising the papers into four data types: descriptive; mixed methods; qualitative; quantitative or mixed methods. This was followed by describing each paper's key phrases, ideas, concepts and grouping papers by each NCD.[23]

3.4.2.4 Data analysis

The data was analysed through an aggregation of individual papers to create an overall data description. The descriptions of NCDs were placed in a matrix to provide an overview of the issues identified. This included columns on the impact on treatment management and care; and the health impacts of cyclone, flood and storm related disasters. This process allowed the impacts and risks to the health and wellbeing of people with NCDs to be systematically identified and described.

3.4.3 *Results*

The search strategy identified 48 relevant articles. Initially 2,388 potentially relevant articles were identified. After a title and abstract review, 2,299 articles were rejected based on exclusion criteria and 89 selected for full text review. After the full text review 56 articles were rejected (including three duplicates), 33 selected for analysis and an additional six identified from the reference lists. The Google Scholar citation list for the 39 relevant articles identified an additional nine articles (Figure 3-7).

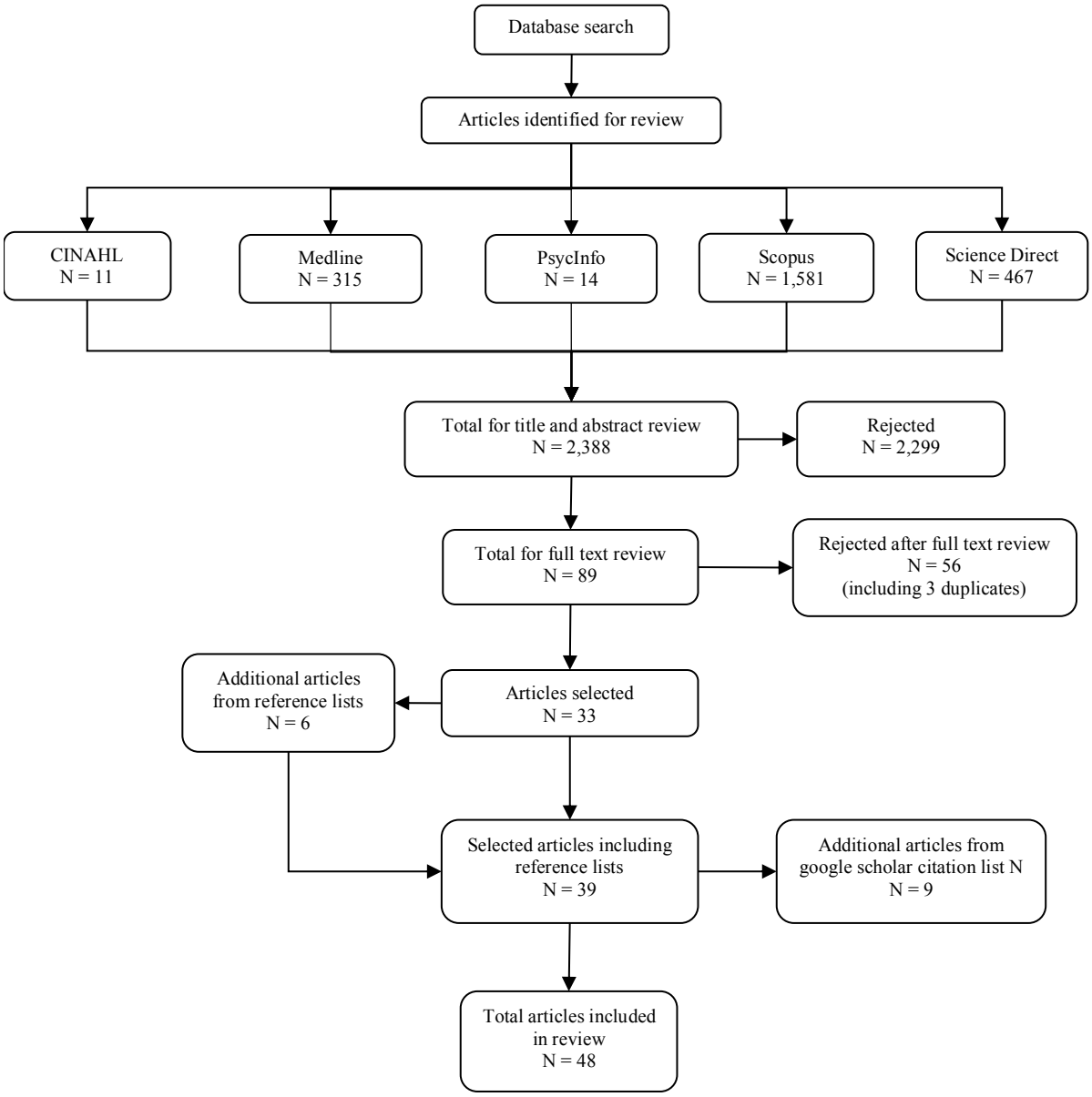

Figure 3-7 Literature flow

The most common data type was a quantitative article (n=24; 50%) followed by descriptive (n=21; 44%), mixed methods (n=2; 4%) and qualitative (n=1; 2%) (Table 3-13). Based on this, it can be estimated that 54% (n=27) of articles were not descriptive.

Table 3-13 Individual case descriptions

Article	Data type	Origin	Description	Noncommunicable diseases	Disaster (name)
Allweiss and Albright, 2011[155]	Description	USA	Describes how disasters can impact people with diabetes.	Diabetes	Hurricane; tornado; flood
Alson et al, 1993[33]	Description	USA	Discusses the medical care provided by a special operations response team after Hurricane Andrew.	Diabetic; myocardial infarction; respiratory stress	Hurricane (Andrew)
Arrieta and Foreman, 2008[156]	Description	USA	Discusses challenges in providing health care to people with chronic diseases.	Cardiovascular disease; cancer; diabetes mellitus; end-stage renal disease; hypertension; respiratory illness	Hurricane (Katrina)
Arrieta et al, 2009[157]	Qualitative	USA	Discusses challenges in providing health care to people with chronic diseases.	Cancer; cardiovascular disease; diabetes mellitus; end stage renal disease; hypertension; respiratory illness	Hurricane (Katrina)
Behr and Diaz, 2013[158]	Description	USA	Overview of vulnerabilities related to chronic diseases by elderly populations.	Arthritis; cancer; chronic obstructive pulmonary disease; diabetes; hypertension	Storms
Brennan, 2009[159]	Description	USA	Describes the impact on the medically underserved.	Anxiety; asthma; blood pressure; cancer; chronic lung disease; depression; diabetes; heart disease; kidney disease; liver disease; seizures; stroke	Hurricanes
Brodie et al, 2006[160]	Quantitative	USA	Examined the experiences of evacuees housed in Houston shelters.	Asthma; diabetes; heart disease; hypertension	Hurricane (Katrina)

Brown et al, 2008[161]	Quantitative	USA	Discusses an evidence-based approach to planning for repositories of chronic disease medications.	Cancer; chronic respiratory diseases; chronic disability; diabetes; heart disease; stroke	Hurricanes
Broz et al, 2009[162]	Description	USA	Analyses the health care provided to evacuees in Chicago	Diabetes; hypertension	Hurricane (Katrina)
Buajaroen, 2013[163]	Mixed methods	Thailand	Identifies lessons from health care services at a Relief Operations Centre.	Diabetes; heart disease; hypertension; stroke	Flood, Thailand
CDC, 1998[164]	Description	USA	Describes the outcome of a community needs assessment after an Ice Storm.	Cardiovascular	Ice Storm 1998
CDC, 2005[165]	Quantitative	USA	Describes the results from an assessment of the impact of four hurricanes in Florida	Asthma; cardiovascular disease; diabetes	Hurricanes
Clements, 2009[73]	Description	USA	Describes the relationship between public health and emergency management in preparedness.	Cardiovascular; COPD; diabetes; respiratory	Flood; tsunami; typhoon; volcano; earthquake
Costello, 2013[166]	Description	USA	Discusses emergencies that may impact public health and nutrition.	Respiratory	Floods; hurricane; earthquake
Crook et al, 2010[167]	Description	USA	Reviews the issues faced by people with hypertension after Hurricane Katrina.	Asthma; COPD; diabetes; end stage renal disease; hypertension	Hurricane (Katrina)
Demaio et al, 2013[133]	Description	Denmark	Describes the threat emergencies pose to people with noncommunicable diseases	Cardiovascular; cancer; diabetes; respiratory conditions	Flood; hurricane; earthquake
Evans, 2010[168]	Description	UK	Explores the vulnerability of older people to catastrophic events.	Cardiovascular disease; diabetes; respiratory conditions	Windstorms, flooding; hurricane; earthquakes

Gautam et al, 2009[169]	Quantitative	USA	Discusses a long-term increase in the incidence of acute myocardial infarction after Hurricane Katrina.	Cardiovascular	Hurricane (Katrina)
Geehr et al, 1989[170]	Quantitative	USA	Describes the impact of a severe winter on five regional hospitals in New York.	Respiratory	Snow storm (1987)
Greenough et al, 2008[171]	Quantitative	USA	Describes the burden of disease in the displaced population living in shelters.	Diabetes; hypertension; hypercholesterolemia; pulmonary disease; psychiatric illness	Hurricane (Katrina)
Hendrickson and Vogt, 1996[35]	Quantitative	USA	Describes mortality data before and after Hurricane Iniki.	Diabetes; cancer; heart disease; respiratory disease; stroke	Hurricane (Iniki)
Hendrickson et al, 1997[172]	Quantitative	USA	Measures health outcomes among the population in the impact zone.	Asthma; cardiovascular disease; coronary artery disease; hypertension; stroke	Hurricane (Iniki)
Howe et al, 2008[173]	Quantitative	USA	Examines patient characteristics, chief complaints, final diagnoses and medications prescribed.	Cardiovascular disease; diabetes	Hurricane (Katrina)
Jhung et al, 2007[174]	Quantitative	USA	Discusses actual medication demands and medical relief pharmaceutical supplies.	Cardiovascular; endocrine; neuropsychotropic; respiratory	Hurricane (Katrina)
Jiao et al, 2012[175]	Quantitative	USA	Discusses the incidence of acute myocardial infarction after Hurricane Katrina	Cardiovascular	Hurricane (Katrina)
Kessler and Group, 2007[176]	Quantitative	USA	Describes the impact of Hurricane Katrina on treatment for people with chronic diseases	Cardiovascular conditions; diabetes; cancer; respiratory illness; HIV/AIDS; renal disease; dementia; mental disorders	Hurricane (Katrina)
Kim et al, 2010[41]	Quantitative	Korea	Assesses patients observed by the Korean Disaster Relief Team.	Asthma; diabetes; hypertension	Cyclone, Myanmar

Lane et al, 2013[177]	Description	USA	Review of the impacts of coastal storms on health.	Cancer; cardiovascular disease; end stage renal disease; hypertension; respiratory illnesses	Storms; flood
Leonard et al, 1997[34]	Description	USA	Describes an outreach program for after Hurricane Marilyn.	Diabetes; respiratory	Hurricane (Marilyn)
Llewellyn, 2006[178]	Description	USA	Describes the impact of floods and tsunamis on health	Asthma; cardiovascular; diabetes	Flood; tsunami
Loehn et alm 2011[179]	Quantitative	USA	Identifies factors affecting access to cancer care.	Cancer	Hurricane (Katrina)
McKinney et al, 2011[180]	Description	USA	Describes direct and indirect mortality in Florida during the 2004 Hurricane season	Cancer; diabetes; heart disease	Hurricanes
Mitchell et al, 2012[181]	Description	USA	Discusses the implementation of counsellor and environmental interventions to address asthma risks.	Respiratory	Hurricane (Katrina)
Mokdad et al, 2005[182]	Description	USA	Describes how chronic conditions can become acute during natural disasters.	Cancer; chronic respiratory disorders; diabetes; heart disease; stroke	Hurricanes
Murakami, 2013[183]	Quantitative	Japan	Explores if different levels of flooding were associated with blood pressure.	Cardiovascular	Japan Tsunami
Nagayoshi et al, 2013[184]	Quantitative	Japan	Investigated the incidence of cardiovascular events after heavy rains in Japan.	Cardiovascular	Rain, Japan
Ng et al, 2011[185]	Quantitative	UK	Examines the impact on the glycaemic control of patients with diabetes.	Diabetes	Flooding, UK

Noji, 1996[186]	Description	USA	Describes the adverse health effects of disasters.	Cardiovascular; respiratory	Cyclone; flood; earthquake; volcano
Omama et al, 2013[187]	Quantitative	Japan	Discusses the occurrence of cerebrovascular diseases after Japan Tsunami	Cardiovascular	Japan Tsunami
Omama et al, 2014[188]	Quantitative	Japan	Assesses the impact on cerebrovascular disease incidences.	Cardiovascular	Japan Tsunami
Rath et al, 2011[189]	Quantitative	USA	Analyses respiratory issues among children affected by Hurricane Katrina.	Respiratory	Hurricane (Katrina)
Rath et al. 2007 [134]	Quantitative	USA	Evaluates differences between children with and without chronic conditions.	Allergies; asthma; attention deficit hyperactivity disorder; autism; chronic lung disease; cystic fibrosis; depression; diabetes; heart disease; HIV/AIDS; kidney failure; liver failure; mental retardation; seizure disorder; sickle-cell disease	Hurricane (Katrina)
Robinson et al, 2011[190]	Mixed methods	Australia	Reviews the pulmonary effects of natural disasters	Respiratory	Tsunami; earthquake; flood; fire
Sharma et al, 2008[191]	Quantitative	USA	Outlines the prevalence of chronic disease visits and related conditions.	Cardiovascular disease; cerebrovascular diseases; chronic lower respiratory disease; diabetes mellitus; hypoglycaemia; renal failure	Hurricane (Katrina)
Shehab et al, 2008[192]	Quantitative	USA	Describes the health care access for displaced residents after Hurricane Katrina.	Not specified	Hurricane (Katrina)

Sotomayor, 2013[193]	Description	Puerto Rico	Analyses the impact of two Hurricanes in Puerto Rico.	Cardiovascular disease; diabetes; high cholesterol; hypertension	Hurricanes
Swerdel et al, 2014[194]	Quantitative	USA	Explores the impact of Hurricane Sandy on cardiovascular events.	Cardiovascular	Hurricane Sandy
Tomio and Sato, 2014[195]	Description	Japan	Recommendations for disaster preparedness for people with chronic diseases.	Cancer; chronic respiratory diseases; diabetes; hypertension	Flood; hurricane; storm; earthquake

Of the 48 articles, 23 (49%) focused specifically on hurricanes, three on tsunamis (7%), two on floods (4%), two on blizzards, snowstorms or ice storms (4%) and one each (1%) for cyclone and mudslide from a rain event. The remaining 16 (33%) focused on more than one disaster type. Of the articles that focused on more than one disaster type: ten included floods, ten hurricanes, three tsunamis, three storms, two cyclones, one typhoon, one windstorm and one tornado. Other disaster types identified, which were not part of this research, were earthquake (n=7), volcano (n=2) and fire (n=1).

The most common disaster discussed was Hurricane Katrina (n=17) followed by the 2011 Japanese Tsunami (n=3) and Hurricane Iniki (n=2). Other disasters discussed (n=1) were the New York Snowstorm (1987), Maine Ice Storm (1998), mudslide due to heavy flooding in Japan in Kagoshimi Prefecture (2012), flooding in Thailand (2010) and Hurricane's Andrew (1992), Marilyn (1995) and Sandy (2012). The remaining articles focused on the general impact of cyclone, flood and storm related disasters. The United States of America (USA) was the origin for the majority of articles (n=36, 74%), followed by Japan (n=5, 10%) and the United Kingdom (n=2, 4%). Other locations (n=1) were Australia, Denmark, Puerto Rico, South Korea and Thailand.

There were 24 different descriptions of NCDs in this research. An additional 21 conditions were also described by the 48 articles reviewed. This provided a total of 45 descriptions for NCDs (Table 3-14). For the NCDs targeted by this research, cardiovascular had the largest number of total descriptions (n=11) followed by chronic respiratory disease (n=8), diabetes (n=4) and cancer (n=1). All descriptions of cancer included the word cancer. The additional 15 descriptions were grouped into mental health (n=10), renal diseases (n=6) and other (n=5). The other conditions were arthritis, cystic fibrosis, HIV/AIDS, sickle cell disease and visual impairment. As mental health, renal diseases and other descriptions identified were not a focus of this research they were excluded from the analysis. This result is further explored in the discussion.

Table 3-14 Noncommunicable disease categories by sub classification

Chronic disease	Description
Cancer	Cancer (n=1)
Cardiovascular	Cardiovascular disease; cerebrovascular diseases; heart disease; high cholesterol; hypercholesterolemia; hyperlipidemia; hypertension; myocardial infarction; stroke symptoms (n=11)
Chronic respiratory disease	Allergies; asthma; chronic lower respiratory disease; chronic lung disease; chronic obstructive pulmonary disease (COPD); pulmonary disease; respiratory conditions; respiratory illness (n=8)
Diabetes	Diabetes; diabetes mellitus; endocrine; hyperglycaemia (n=4)
Renal diseases	Kidney disease; end stage renal disease; kidney failure; liver failure; renal failure; rhinosinusitis (n=6)
Mental health	Anxiety; attention deficit hyperactivity disorder; autism; behaviour problems; depression; mental disorders; mental health; mental retardation; psychiatric illness; seizure disorder (n=10)
Other	Arthritis; cystic fibrosis; HIV/AIDS; sickle cell disease; visual impairment (n=5)

3.4.3.1 Data Analysis – Impact, treatment management and care

The data was analysed according to the impact of a disaster on specific and non-specific NCDs; treatment, care and services; and the health impact (for example, exacerbation of existing NCD). The category of non-specific NCDs was used because there were a number of articles that described the impact of disasters on more than one NCD. The analysis is provided in Table 3-15 and described in the following.

Table 3-15 Impact on treatment, care and services and the consequences for people with NCDs

NCD	Impact on treatment management and care	Health impact for people with NCDs
Cancer	Reduced access to transport, clinics, specialists, medications and hospitals.[179,180]	19% increase in cancer related deaths in the 12 months following Hurricane Iniki (1992).[168,183]
		After the four hurricanes impacting Florida in 2004, cancer related deaths accounted for 19% of excess deaths: Charlie 16%, elevated for 24 days; Frances/Jeanne 17%, elevated for 16/20 days; and Ivan 32%, elevated for 37 days.[33]
		After Hurricane Katrina (2005), there was anecdotal evidence of an increased incidence of patients presenting with advanced head and neck cancers.[191]
Cardiovascular disease	Reduced access to medication and medical care.[175,183,191]	Severe exacerbations and complications such as higher blood pressure, heart attack or even death.[164,169,175,179,183,191]
	Delayed access to supplies.[178]	After Hurricane Iniki (1992) the number of cardiac visits increased by 173%.[194]
	Increased medical noncompliance. [172]	In the ten days after the Maine Ice storm (1998), cardiac complaints increased by 9.5%.[184]
		Three-fold increase in myocardial infarction (MI) incidents two, three and six years after Hurricane Katrina (2005).[134,180]
		In the 30 days post Hurricane Sandy (2012), MI incidence increased by 22% and mortality by 31%.[168]
		The incidence of cardiac presentations after mudslides in southwest Japan (2012) increased by 373% compared to the month prior. [170]
		After four hurricanes impacting Florida in 2004, cardiac related deaths accounted for 34% of excess deaths.[190]

Chronic respiratory diseases	Disruption to care, treatment, medication and health systems.[73,166,170,172,190,195] Loss of power for equipment such as nebulisers and oxygen.[134,168,181] Increase in mold growth.[172]	40% of children self-reported asthma had worsened in the three months after Hurricane Katrina (2005).[172] 3% of children began using asthma medication or inhalers in the three months after Hurricane Katrina (2005).[189] Shortness of breath was a key symptom experienced by the Katrina-displaced population in 2005, with 13% of people reporting a pre-existing lung disease.[163] In the two weeks after Hurricane Iniki (1992), physician visits for asthma increased by 181%.[185] Asthma admissions were three times higher in the two weeks after Hurricane Iniki (1992).[168] 24% of children evacuated for Hurricane Katrina (2005) ran out of asthma medications or were afraid of running out of asthma medications.[155]
Diabetes	Disruption to glucose monitoring, medical check-ups, medication, treatment, care, activity patterns and nutrition.[35,133,157,159,173,178,191,193] Loss of power impacting on insulin storage.[157]	Without appropriate care following a disaster, people with diabetes may experience severe exacerbations such as diabetic ketoacidosis or even death.[35,155] After Hurricanes in Puerto Rico (1928 and 1932) there was a 6.8% increase in diabetes incidence.[133,191] In the 12 months after flooding in Hull (2007), England, glycaemic control deteriorated. This was worse for people reliant on insulin treatment compared to lifestyle and oral treatments.[180] In the 12 months after Hurricane Iniki (1992) in Kauai, Hawaii, diabetes-related deaths increased by 161%.[178,180,195] After the four hurricanes impacting Florida in 2004, diabetes related deaths accounted for 5% of excess deaths.[157,179]

NCD-non specific	Limited access to treatment, care, specialists, medications, health system, information, communication and transport.[89,133,156,157,160,176,182,186] Lack of food, clean water.[119,133,168] Forgetting prescription medication when being evacuated to shelters.[134,167]	After a disaster there is a worsening of underlying cardiovascular and respiratory diseases, and instability of diabetes, renal diseases, asthma and COPD.[134,158,165,167,173,178,191] After Katrina (2005), NCDs were the overwhelming sources of immediate demands at evacuation centres, mobile clinics and Federation Emergency Management Agency (FEMA) trailer parks.[168,174,196] In the two months after Hurricane Katrina (2005) people with NCDs were more likely to present at a clinic than those without (43.5 vs.16.2%).[192] After Hurricane Katrina (2005), 33.4% of evacuees exhibited signs of acute exacerbation of a chronic illness when arriving at a shelter.[168] 68% of medications dispensed to Hurricane Katrina (2005) evacuees were for treatment of NCDs.[174] 42%of presentations one month after Cyclone Nargis (2008) were for chronic conditions, many of which were poorly controlled.[196] In Mississippi trailer parks three years after Hurricane Katrina (2005), 58% adults perceived worsening of chronic condition, and this was 68% for children.[192]

3.4.3.1.1 Cancer

For people with cancer, a disaster can reduce access to transport, clinics, specialists, medications and hospitals.[163,179] This often results in a reduction in access to cancer treatment management and care, which based on experiences from Hurricane Katrina can last for up to one year.[197] However, no evidence was found that a person with cancer was at risk of their illness exacerbating after a disaster. Ultimately the consequence for people with cancer is an increased risk of premature death.[35, 180]

3.4.3.1.2 Cardiovascular Disease

Without appropriate care following a disaster, people with cardiovascular disease are at risk of severe exacerbation or complications of their illness such as high blood-pressure, heart attack or even death.[73,164,167-169,172,177,178,183,184,187,188,191] This risk can continue for weeks or in the case of Hurricane Katrina years.[164,169,172,177,184,194] This is generally due to limited access to medication, care and supplies; medical noncompliance; and the physical workload associated with clean-up and reconstruction.[33,133,168,175,183,187,188,191] These factors culminate in people with cardiovascular diseases being at an increased risk after a disaster of severe exacerbation of their illness which can result in premature/preventable death.[180,194]

3.4.3.1.3 Chronic Respiratory Disease

There is an increased risk of people with chronic respiratory diseases having acute exacerbations after a disaster.[73,166,190,198] There is often an increase in physician visits and hospital admissions related to chronic respiratory diseases after a disaster.[172, 189] These exacerbations are due to a disruption in care, treatment, medication, supplies, equipment, loss of power (particularly for oxygen and nebuliser dependent patients) and overcrowding in shelters.[73,166,190,195, 34,168,170] The high levels of mould and other allergens after a disaster are other factors increasing the risk of acute exacerbation.[181] The review confirmed that people with chronic respiratory diseases are at an increased risk of death after a disaster.

3.4.3.1.4 Diabetes

Without appropriate care following a disaster, people with diabetes are at risk of severe exacerbations or even death all of which are preventable.[35,133,155,168,185,191,193] This risk can

continue for months following the event.[185] This is due to disrupted treatment, poor nutrition, loss of power for insulin storage, limited physical activity, damaged medication, lost prescriptions and disrupted activity patterns.[34,35,155,157,159,163,173,185] The greatest risk is found in people reliant on insulin.[163,185]

3.4.3.1.5 NCD-non specific

Disasters can cause an exacerbation of NCDs or even death due to the limited access to treatment, care, medications and transport; lack of food and clean water; and increased exposure to extremes of cold or heat.[89,133,156,157,160,162,176,182,186] Another risk factor is that people with NCDs are often evacuated without sufficient supplies of medication and pharmaceutical scripts/re-fills.[159, 158,171,174] It is common for evacuated people to no longer have access to the care they require.[160] From a patient perspective, these factors often result in a perceived worsening of their condition, which can have negative impacts on their actual illness.[192] For people with NCDs, a lack of treatment management and care for even a short period can result in severe exacerbations and preventable death.[133,165,178,195,196]

3.4.4 *Discussion*

Cyclone, flood and storm related disasters interrupt treatment management and care for people with NCDs. This results in an increased risk of disease exacerbation or even death due to a range of factors, including damaged transport routes, unsafe water, reduced health services, loss of power and evacuations.[73,89,133,134,156,157,160,166,168,170-172,175,176,179-183,186,190,191,195] A lack of appropriate care for even a short period of time puts the health and wellbeing of people with NCDs at risk.[199,200] This is because people with NCDs are more vulnerable than others to the stresses and disruptions of a disaster.[182]

The impact of an interruption to treatment management and care varies according to the NCD. For people with cancer there is an increased risk of death, however, no evidence of a worsening in conditions.[35, 180] Cardiovascular incidents increase with exacerbations and complications such as higher blood pressure, heart attack and increased death rates.[164,167,169,172,177,178,180,183,184,191,194] Chronic respiratory diseases are associated with acute exacerbation but no increase in death rates.[134,168,172,189] People with diabetes experienced severe exacerbations, such as diabetic ketoacidosis, and an increased death rate with the risk greatest for insulin dependent diabetics.[35,133,155,178,180,185,191,193]

The reason for the variation in impact by NCD is due to the type of disruption to treatment management and care. For people with cancer, the increase in deaths can be associated with reduced access to transport, clinics, specialists, medications and hospitals.[163,179,197] The situation for people with cardiovascular diseases is similar, however, delayed access to medical care and increased medication noncompliance are associated with exacerbations or even death.[33,168,175,183,191] An exacerbation of a chronic respiratory disease is due to similar factors with a loss of power for equipment, such as nebulisers and oxygen, and mould growth additional issues.[166,168,170,172,181,189,195] For people with diabetes an interruption to glucose monitoring, activity patterns and a loss of power for insulin storage increases the risk of exacerbation or even death.[35,155,157,159,163,168,173,185]

The long-term health complications for people with NCDs requires further investigation. For example, uncontrolled diabetes for extended periods can result in heart disease (heart attacks and strokes), blindness, kidney failure and lower-extremity amputations.[146,201-203] However, for diabetics and people with other NCDs there is limited data on the long term health complications associated with a disruption to treatment management and care due to a disaster. Understanding this, including the impact of reduced treatment efficacy, will provide a new paradigm for mitigating the impact of disasters on people with NCDs.

A challenge faced by this research and future studies is the range of descriptions for NCDs. NCDs are difficult to define because this group includes some diseases partly caused by infectious organisms (for example, cancers of the liver, stomach, and cervix) and usually excludes mental illnesses.[204] When researching NCDs all variations (forms of the disease) should be considered, for example, chronic respiratory disease can include COPD and asthma. Of the NCDs subject to this research, cancer was the only condition where a single term can be used. It is recommended that future research focused on NCDs, as a collective, is guided by the major NCDs identified by WHO (cancer, cardiovascular, chronic respiratory and diabetes).

The review and subsequent analysis was limited to articles that predominately originated from high-income countries. Although this could be considered a limitation in the transferability of the findings, NCDs now disproportionately affect low and middle income countries.[205,206] In African nations NCDs are rising rapidly and are projected to exceed communicable, maternal, perinatal, and nutritional diseases as the most common causes of death by 2030.[207] However,

caution should still be taken in applying the results to low and middle income countries as NCD priorities may change.

To mitigate the risk that disasters pose to people with NCDs, a multi-sectoral approach is required. NCD treatment, care and services is reliant on more than just health services.[208] For example, damage to transport routes prevents access to specialists, medications, nutritious food and health facilities and a loss of power is a threat for people reliant on electricity for insulin and oxygen.[89,157,170,172,179,182,190,195,197,209] This interdependency highlights the need to mainstream health in disaster risk reduction activities at local, national and international levels.[209]

This research provides the platform required for expanding traditional disaster approaches by public health to incorporate NCDs. The reality of this need has been acknowledged in the Sendai Framework in the statement (30(k)) that chronic diseases (NCDs) need to be included in the design of disaster policies and plans.[130] Specific measures may include cross-cutting disaster strategies such as multi-sectoral approaches to protect equipment/infrastructure, mapping health vulnerabilities within a community and stockpiling medicines.[210,211] The aim is to ensure people with NCDs have access to life-saving services during and after disasters.[130]

To build on this research, the next step is to understand all the factors that influence both direct and indirect (preventable) morbidity and mortality related to NCDs during and after disasters. This includes quantifying acute complications, long-term complications and disease progression (including long-term health complications and impacts of reduced treatment efficacy). Once achieved, disaster planners and public health professionals will be in a position to develop and implement effective and evidence-based mitigation strategies.

3.4.5 *Limitations*

The research was influenced by the lead author's studies and work in public health and disaster management in Australia at local, state and national levels and across the Asia-Pacific. To address this, an integrative methodology was selected to systematically identify and describe the literature. This included searching multiple databases and excluding grey and non-peer-reviewed literature. Papers were only selected if they were peer-reviewed and discussed cyclone, flood or storm related disasters and the impact on people with NCDs.

A limitation of this research is the narrow focus on the NCDs investigated: cancer; cardiovascular diseases; chronic respiratory diseases; and diabetes. This approach was selected to ensure consistency with the four major disease groupings for NCDs by the World Health Organization. However, other NCDs may be impacted more significantly by a disaster. For this reason, caution should be taken in applying the results to other NCDs.

3.4.6 *Funding*

This research was part of doctorate studies at James Cook University, Australia. The research was supported by funding from the Australian Centre for Health Service Innovation and Cunningham Centre / Toowoomba Hospital Foundation, Australia. The Cairns and Hinterland Hospital and Health Service, Queensland, Australia, provided in kind support.

3.4.7 *Conclusion*

Cyclone, flood and storm related disasters impact on treatment management and overall care for people with NCDs. This results in an increased risk of exacerbation of illness or even death. The interruption may be caused by a range of factors, such as damaged transport routes, reduced health services, loss of power and evacuations. The health impact varies according to the NCD. For people with chronic respiratory diseases, a disaster increases the risk of acute exacerbation. Meanwhile, for people with cancer, cardiovascular diseases and diabetes there is an increased risk of their illness exacerbating, which can result in death. To address this problem, there is a need to expand traditional disaster approaches by public health to incorporate NCDs. The reality of this need is further highlighted by the statements in the Sendai Framework. Specific measures may in include a multi-sectoral approach to ensure people with NCDs have access to life-saving services during and after disasters. To achieve this, the next step is to understand all the factors that influence both direct and indirect (preventable) morbidity and mortality related to NCDs during and after disasters. Once achieved, disaster planners and public health professionals will be in a position to develop and implement effective and evidence-based mitigation strategies.

3.5 Synthesis

All three papers presented in this Chapter were interrelated and informed the next phase of this research, focus group and interviews (Chapter 4). Paper one found Severe Tropical Cyclone Yasi and other similar events around the world can breakdown PHI and subsequently impact on the management of NCDs. Paper two found the workforce was the most important of the 13 thematic areas related to PHI and disasters. This was followed by water, sanitation, equipment, communication, physical structure, power, governance, prevention, supplies, service, transport and surveillance. If the workforce functionality fails, it has the greatest impact on the performance of health services. If addressed post disaster, the remaining forms of PHI will then be progressively addressed. Meanwhile, paper three found the people with NCDs at greatest risk post disaster are those with underlying cardiovascular and respiratory diseases, undergoing cancer treatment, unstable diabetes and renal diseases.[2,133,134,165,167,168,173,178]

This Chapter laid the foundation for identifying, developing and implementing strategies to reduce the impact of disasters on people with NCDs. This included understanding areas for improvement, options for enhancing PHI resilience, strategies for maintaining treatment, care and services and how the research could be extrapolated to similar disaster types around the world. All of which provided evidence on the need to expand traditional disaster approaches and research by public health beyond communicable disease and immediate trauma to include NCDs. In addition, the findings provided an evidence-base to further understand the factors that influence both direct and indirect (preventable) morbidity and mortality related to NCDs during and after disasters. For example, a disruption to PHI from a cyclone, flood or storm related disaster could reduce access to treatment, care and services for people with NCDs, which can result in exacerbation of illness, complications or even death.

The purpose of the next research phase is to build on this Chapter by further investigating the impact of cyclone, flood and storm related disasters on PHI and NCDs, and identify mitigation strategies through interviews and focus groups with disaster service providers and people with NCDs.

3.6 Developments since literature reviews

Since the database searches and publication of the literature reviews, there have been developments particularly relating to the management of NCDs before, during and after a disaster. The literature search for the cyclone Yasi paper was completed in May 2013 and publication in 2015. The defining, describing and categorising PHI literature search had a date limit of December 2013 and publication 2016. The data collection for the paper that identified the impact of disasters on people with NCDs was completed in December 2014 and publication 2015. Since the data collection processes, the Sendai Framework was adopted, workshops with a focus on the primary healthcare sector rolled out in northern Queensland, Australia, and generally an increased awareness through publications.

3.6.1 *Sendai Framework*

The Sendai Framework was adopted on 18 March 2015 by 187 UN Members States.[130] The Sendai Framework, a 15-year agreement, has science firmly at the core of the priorities for action and in the principle of "risk-informed decision-making".[212] Compared to the past when disaster agencies focused on safety regulations and recovery, agencies following this "people-centred" approach now seek to transfer risk management responsibility from the government to the citizens, demanding precautionary actions that are appropriate for their unique situations.[213] The needs of people with NCDs was recognised in the Sendai Framework with item 30(k) recommending people with NCDs be part of policy design and plans to manage risks before, during and after disasters, including access to life-saving services.[130,214]

3.6.2 *Primary healthcare sector*

The UNISDR Office for Northeast Asia and Global Education and Training Institute partnered with the Northern Queensland Primary Health Network, Australia, to deliver capacity building workshops for the primary health sector.[215] The author of this PhD led implementation of the workshops in Cairns, Townsville and Mackay to explore the feasibility of integrating the Sendai Framework into primary health networks in Australia.[216] This sector was targeted because its role is not clearly defined in disaster management, however, it provides the majority of treatment, care and services for people with NCDs.[217-219] The workshops identified the role of primary healthcare can be strengthened if the disaster management stakeholders recognise

the vital role in supporting the needs of people with NCDs before, during and after a disaster.[216] The benefit of this was highlighted in the response to Severe Tropical Cyclone Debbie (Queensland, Australia) in March 2017. For the first time, health assessments for evacuees arriving Cairns were conducted by a member organisation of the primary health network (initiated by the PhD researcher through his role in disaster management).

3.6.3 *Publications*

Since the literature reviews, there has been an increased awareness of the need to maintain treatment, care and services for people with NCDs before, during and after a disaster. This has included the PhD researcher being a co-author in a chapter for a book titled *Disaster Health Management: Primer for Students and Practitioners*, where NCDs were discussed.[220] This complemented his role as an expert advisor for the guideline *Natural Disasters: A Guide for Emergency Services, Local Councils and the Not-for-Profit Sector*, which highlighted the needs of people with NCDs.[221] Also, WHO published in 2016 the guide *Noncommunicable Diseases in Emergencies*, however, this high-level document did not incorporate the perspectives of disaster service providers and people with NCDs.[222]

There have been additional peer-reviewed publications describing the impact of disasters people with NCDs since the literature reviews. These include: studies on the Nepal and Italian earthquakes on people with cancer[223,224]; a systematic review on the impact of disasters on people with diabetes[225] and after Hurricane Sandy[226]; characterisation of hospital admissions after typhoon Haiyan[227]; general discussion about care of NCDs in emergencies[228]; and how the Sendai Framework can help protect the health and wellbeing of people with NCDs from disasters[229,230]. These publications provide further evidence but, again, do not propose mitigation strategies based on the perspectives of disaster service providers and people with NCDs (the focus on this research).

3.7 Conclusion

Cyclone, flood and storm related disasters impact on PHI, which reduces treatment management and care for people with NCDs. Possible consequences include exacerbation of illness, worsening prognoses or even death. This risk can be extrapolated across the world where there are similar disaster types and profiles as Queensland, Australia. The workforce

was identified as the most important form of PHI in the disaster setting. If its functionality fails, it has the greatest impact on the performance of health services. This was followed by water, sanitation, equipment, communication, physical structure, power, governance, prevention, supplies, service, transport and surveillance. If the workforce issues are addressed post disaster, the remaining forms of PHI will then be progressively resolved. The people with NCDs at greatest risk are those with underlying cardiovascular and respiratory diseases, undergoing cancer treatment, unstable diabetes and renal diseases. There is now a need to expand traditional disaster approaches by disaster and health planners to incorporate NCDs. These findings provide a step towards an evidence for PHI priorities and mitigation strategies that can reduce the impact of disasters on people with NCDs.

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Chapter 4 Focus Groups and Interviews

4.1 Overview

This Chapter investigates the impact of disasters on public health infrastructure (PHI) and the management of noncommunicable diseases (NCD), and develops strategies for mitigating the risks identified. This included focus groups and interviews with: environmental health professionals (via focus groups)[1]; disaster service providers (via interviews and a focus group)[2]; and people with NCDs (via interviews). The objectives were to: identify and describe the impact of disasters on PHI and the management of NCDs; investigate the knowledge and experience disaster service providers have about the impact of disasters on PHI and the management of NCDs; investigate the impact disasters can have on people with NCDs; and identify how the risks identified can be mitigated.

This Chapter is divided into three papers, with two published.[1,2] The papers focused on: environmental health professionals (4.2)[1]; disaster service providers (4.3)[2]; and people with NCDs (4.4). Combing into one section would have missed the challenges, nuances and recommendations presented by each group. For example, environmental health professionals address risks related to drinking water, sanitation and food safety.[3,4] Disaster service providers provide overall leadership and system-wide management.[5] People with NCDs represent the group at greatest risk of disease exacerbation post disaster.[6] These papers are described in the following along with a synthesis of how they create a platform for the next research phase (Chapter 5).

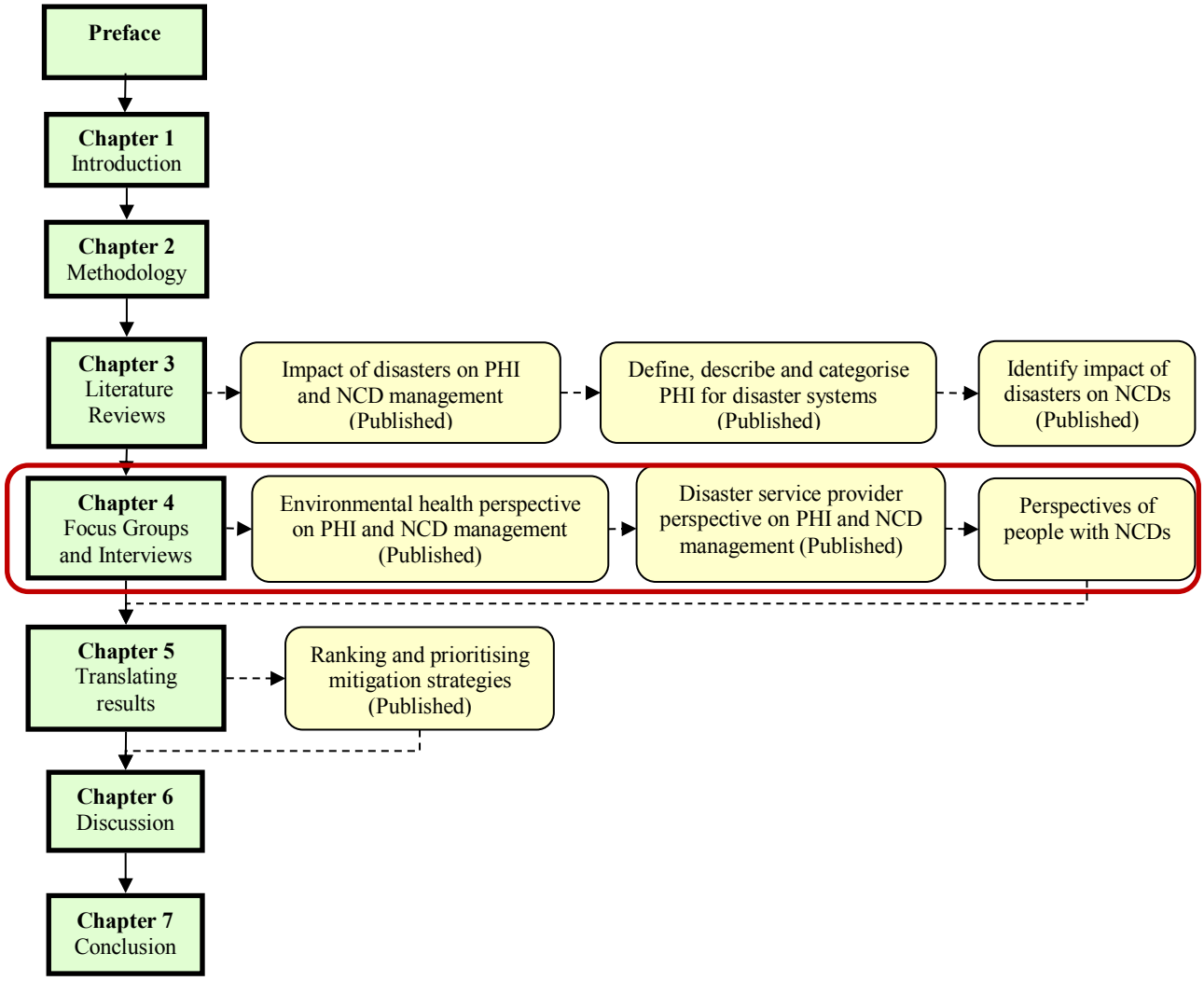

Figure 4-1 Chapter 4 position within thesis

4.2 Environmental health perspective on public health infrastructure and noncommunicable disease management

Published – Ryan BJ, Franklin RC, Burkle FM, Watt K, Smith EC, Aitken P, Watt K and Leggat P (2017). The role of environmental health in understanding and mitigating post-disaster non-communicable diseases: The critical need for improved multidisciplinary solutions. Journal of Environmental Health. Vol 80(5):38-50. . Impact factor 0.927 (Thomson Reuters 2017); Indexing CABI, EBSCOhost, Elsevier BV, Gale, H.W. Wilson, International Atomic Energy Agency, National Library of Medicine, OCLC, Ovid, Pan American Health Organization, ProQuest, Safe Publications, Thomson Reuters and U.S. National Library of Medicine; Google Scholar citations 3 – Appendix D.

4.2.1 *Introduction*

The frequency, intensity and severity of natural disasters across the globe has increased in recent decades.[6-11] The majority of these natural disasters have been the result of cyclones, hurricanes, typhoons, floods, tsunamis or storms (88%).[12] During the past 20 years the exposure of people and infrastructure to risk in all countries has increased faster than vulnerability has decreased.[2,13,14] This increasing vulnerability highlights the need to focus resources on assisting the most vulnerable people affected, both directly and indirectly, by a disaster.[10]

Traditionally the focus of public health before, during and after disaster has been on communicable diseases. However, the actual risk is low, particularly in developed countries.[15] A combination of population aging, increasing obesity and overweight, decreasing physical activity, environmental change and reduction in communicable disease in populations across the world has contributed to a disease transition to noncommunicable diseases (NCDs).[16-19] This transition poses a new challenge for disaster management and health systems.[20,21]

Any disruption to PHI such as: medical access or availability, lack or quality of water or poor sanitation can result in an exacerbation of NCDs or even death.[10,19,22-27] Arguably this risk was first highlighted by the 47% increase in mortality one year after Hurricane Katrina, which can

be attributed to NCDs.[11] People at greatest are those with cancer, cardiovascular diseases, diabetes, respiratory conditions and renal diseases.[6,28-33]

This challenge has been recognised globally by the United Nations in the *Sendai Framework for Disaster Risk Reduction 2015-2030* (Sendai Framework). Item 30(k) suggests that NCDs should be included in the design of policies and plans to manage risks before, during and after disasters, including having access to life-saving services.[13]

In Australia, NCDs cause approximately 90% of all deaths, account for 88% of the burden of disease and are responsible for 83% of recurrent health expenditure.[34] The challenge of managing NCDs stems from a lack of initial understanding of the problem and a shortage of appropriate mitigation strategies.[35] Health care providers typically focus on the treatment aspects of NCDs with a tendency to be response oriented.[36,37] This alone will not either mitigate or solve the problems NCDs have exposed on society. The challenges posed by NCDs encompass a range of disciplines and for this reason requires an interdisciplinary approach.[38-41]

The environmental health discipline takes an interdisciplinary approach to providing a strong basis for good public health outcomes for individuals and communities.[42] In a disaster situation, particularly in Queensland, Australia, the profession works across and with disciplines to address risks relating to: drinking water; hazardous; general waste; sanitation; food safety; communicable diseases; vector issues; and mass gatherings.[4,43] All of which can be considered vital for maximising treatment, care and services for people with NCDs before, during and after a disaster.[43-45]

It is the interdisciplinary characteristics of environmental health and the indirect, but vital, role in maximising treatment, care and services for people with NCDs that demonstrates the profession is an essential resource in helping address this problem. This research builds on this proposal by exploring current and potential roles of environmental health in helping understand and mitigate the impact of cyclone, hurricane, typhoon, flood, typhoon and storm related disasters on people with NCDs. This includes exploring the areas of environmental health that are crucial to understanding the "how and why" factors that contribute to NCDs and whether that knowledge might lead to improved mitigation of the impact of disasters on people suffering from NCDs.

4.2.2 *Methods*

Data was collected through five focus groups with 55 participants from March to August 2014 in Queensland, Australia. Two focus groups were held in the South-West of the State (Roma) and three in North Queensland (Malanda (n=2) and Townsville (n=1)). The focus groups were transcribed and the data analysed through the phases of: organising data; data description; and data classification and interpretation.[46-49] The geographical location and demographics for the research along with a description of the analysis phases is provided in the following.

4.2.2.1 Geographical location and demographics

The research was conducted in the Cairns and Hinterland, Darling Downs and Townsville Hospital and Health Services (HHS) in Queensland, Australia. These locations are regional and rural areas, have a high burden of NCDs and experienced significant natural disasters in recent years.[50,51] For example, Severe Tropical Cyclone Larry (2006), flash flooding in the Lockyer Valley (2011); Severe Tropical Cyclone Yasi (2011); flooding in Bundaberg (2013); and Tropical Cyclone Nathan (2015).[52]

The Cairns and Hinterland HHS supports a population of just over 280,000 and 9% of the population are Indigenous Australians, compared to 3.5% for Queensland.[53] The Townsville HHS services a population of approximately 240,000 and 7% are Indigenous Australians.[54] The Darling Downs HHS population is just under 280,000 people and Indigenous Australians make up 4.2% of the population.[55]

4.2.2.2 Data collection

A questionnaire was developed to guide the discussion and help focus on understanding the direct role environmental health professionals could have in mitigating the impact of disasters on people with NCDs. The questions related to the participant's experience in disaster management, examples of PHI and the relationship with NCDs, how disasters can impact on people with NCDs, mitigation options and the role of environmental health.

A purposive sampling strategy was used to select and recruit participants. Participants included environmental health academics, officers, professionals and specialists (referred to as environmental health professionals). This group was selected because their perceptions,

experiences and activities are considered crucial in influencing disaster preparations, responses and recovery for cyclone, hurricane, typhoon, flood, typhoon and storm related disasters.

The focus groups were held as part of regional conferences in Malanda (North Queensland Conference) and Roma (South-West Queensland Conference). The Townsville focus group was held as part of an annual Environmental Health and Disaster Management course.

The principle of saturation was used to determine the number of focus groups.[46,47,56,57] The point of saturation was achieved after four focus groups. The fifth focus group did not generate any new information.

4.2.2.3 Data Analysis

The information from focus groups was transcribed and thematically analysed using a combination of electronic analysis in QSR NVivo 10 and Microsoft Excel™. The analysis was undertaken by the lead author and was checked by the second author for clarity and consistency.

4.2.2.3.1 Public Health Infrastructure themes for analysis

The PHI themes identified by Ryan et al (2016) in the disaster setting were used to guide the data description, classification and interpretation.[58] For this reason the PHI described by participants was grouped into the themes of: communication; equipment; governance; physical structure; power; prevention; sanitation; services; supplies; surveillance; transport; water; and workforce.[59] During the analysis another category of "Other" was created for any data that did not align with the PHI themes. This process also provided an opportunity to validate PHI themes and priorities before, during and after a disaster.

4.2.2.4 Noncommunicable disease terms for analysis

The terms used to guide the analysis were based on the NCDs with the highest burden in Queensland, Australia, and those considered at greatest risk post disaster due to their reliance on PHI for treatment, care and services.[51,60] These NCDs included cardiovascular diseases, cancers, respiratory conditions and diabetes. The focus was people who already had a NCD rather than those who may have developed a condition due to disaster exposure. During the analysis, three additional themes for NCDs were identified and used: renal diseases; NCD-general; and other.

4.2.2.5 Ethics

Ethics approval was provided by James Cook University (H4871), Australia, and Townsville Hospital and Health Service Human Research Ethics Committee (HREC/13/QTHS/251).

4.2.3 *Results*

4.2.3.1 Participants

All of the 55 participants, except one, had experienced a disaster professionally (85%; n=47) and/or personally (38%; n=21). Of this group, 15% (n=8) had experienced a disaster both professionally and personally. The most common disaster type experienced professionally was a flood (31%; n=17) followed by a combination of cyclone (included hurricane and typhoon), flood, storm, tornado, tsunami or fire (43%; n=20); cyclone (21%; n=14); and an earthquake (2%; n=1). From a personal perspective, a flood (43%; n=9) was the most common followed by multiple disaster types such as cyclone, flood, storm or fire (29%; n=6); cyclone (24%; n=5) and an earthquake (5%; n=1).

The disasters experienced were predominately cyclones, floods and storms in Queensland, Australia. Other disaster types experienced included: Indian Ocean Tsunami, Maldives (2004); Hurricane Katrina, United States of America (USA) (2005); bushfires in Victoria, Australia (2009); earthquake Christchurch, New Zealand (2010); and tornadoes in Tuscaloosa–Birmingham, USA (2011).

The majority of participants were from government agencies (84%; n=46). This included 60% (n=33) from local government and 24% (n=13) state government. The remaining participants were from non-government organisations (7%; n=4); students (4%; n=2) and from outside Australia (5%; n=3). The participants from outside Australia were from New Zealand (n=1), Papua New Guinea (n=1) and United States of America (n=1).

The majority (67%) of participants identified their current role as an environmental health officer (n=37). This was followed by: environmental health manager (n=7); environmental health coordinator (n=3); health promotion (n=3); student (n=2); other roles including general practitioner (n=1), administration (n=1) and project manager (n=1).

4.2.3.2 Public Health Infrastructure descriptors

The focus groups identified 182 different descriptors of PHI, which were grouped into 14 themes. In comparison Ryan et al (2016) identified 167 different descriptors for PHI in the literature, which was grouped into 13 themes.[59] The PHI themes used in this research included: communication; equipment; governance; physical structure; power; prevention; sanitation; services; supplies; surveillance; transport; water; workforce; and other. The data was analysed by identifying similarities and comparing the number of descriptors identified in the literature and focus group descriptors. The data is provided in Table 4-1.

Table 4-1 Descriptions of public health infrastructure

Theme	Descriptors similar with literature	Focus group descriptors (n=focus group; n=literature)
Communication	Information systems (sheets): social media; telephone.	Community meeting; community messaging; education/training; Facebook; information sheets; newspaper; police communication; social media; SMS; Twitter; telephone; radio; television (n=14; n=18).
Equipment	Beds (bedding).	Bedding; camp beds; cooking facilities; earthmoving equipment; mattress; trucks (n=7; n=9).
Governance	Command, control and coordination; disaster system; government.	Command, control and coordination; disaster plan; District Disaster Management Group; emergency; environmental health; evacuation; evacuation plans; exercising plan; Federal Government; food safety; legislation; Local Disaster Management Group; policies and procedures; private business; public health plan; State Government; sustained education programs (n=17; n=14).
Physical structure	Hospitals (health facilities); housing; shelters.	Accommodation; boating facilities; camps; caravan parks; churches; community hall; cyclone shelters; evacuation centres; food storage; hospitals; housing; licensed premises/business; local council building; medical centre; PCYC; places of refuge; private home; schools; sewerage treatment plant; shelters; showgrounds; sports venue (n=23; n=16).
Power	Generators; power; power supply.	Back-up generators; fuel supply; generators; power; power supply (n=5; n=8).
Prevention	Prevention (of disease).	Disease control; prevention of disease (n=2; n=4).
Sanitation	Hygiene (personal); medical waste (management); sewage (systems); solid waste (collection); waste disposal (facilities); waste management; water treatment (plants).	Asbestos management; central washing area; clean-up of putrescibles; environmental health inspections of houses; landfill; medical waste management; personal hygiene; septic; sewage; sewerage supply; sewerage treatment; showers/bathe; solid waste; treatment; toilet paper; toilets; toothbrush; toothpaste; waste; waste disposal facilities; waste facilities; waste management; waste; water treatment plants; water purification; water sampling; water (n=27; n=14).

Services	Education (educating public); environmental health (inspections and assessments); food safety (inspections); healthcare (providers/program); health promotion; nursing homes; pharmacies.	Access to medication; asbestos clean-up; catering; childcare centre; cleaning services/facilities; community health centres; community-related services; dental services; doctors surgeries; doctors; educating public; environmental health inspections and assessments; food premises; food safety inspections; general practice; healthcare; health promotion; health-related services; inspecting septic systems; inspections of evacuation centres; licensed premises; medical care; medication dispensing; medication supply; medication; mobile morgues; morgues; mosquito control; mosquito response; nursing homes; oxygen; pharmacies; pharmacist; public and private hospitals; setting up evacuation centres (n=35;n=34).
Supplies	Food; food supply; fuel; medication(s); pharmaceuticals (supplies); water (sources)	Compounding pharmacies; drug supplies; first aid kits; food; food supplies; fuel for generators; fuel; medication; medical supplies; medication supply; oxygen supplies; pharmaceuticals; pharmacist; water (n=14; n=16).
Surveillance	Assessment; health data (data collection).	Damage assessment; statistics on status of food premises; data collection; health records; personal information; public health data; surveys of evacuation centres prior to activation; understanding disease priorities (n=8; n=6).
Transport	Aircraft/airport; roads; road/transport network; transportation.	Access to laboratory services; access to waste landfill; aircraft; delivering drugs; evacuation; floating medication; helicopter; logistics; road network; roads; transport network; transport; transportation; trucks (n=14; n=9).
Water	Dams/reservoir; water supply.	Reservoir; town water supply; water bottles; water supply (n=4; n=4).
Workforce	Nurses; pharmacist; public health officials / environmental health officers.	Contractors; doctor at evacuation centre; doctors; electrical contractors; engineers; environmental health officers; nurses; pharmacist; volunteer groups (n=9; n=15).
Other	N/A	Animals (chickens) at evacuation centres; pet care; pound. (n=4)

4.2.3.3 Disasters impact on public health infrastructure

The participants described various impacts of disasters on PHI and proposed resilience strategies (Table 4-2). These findings are described in the following.

Table 4-2 Reported impact of disasters on PHI and proposed resilience strategies

Public Health Infrastructure	Reported Impact	Proposed Resilience strategies
Communication	Social media resulting in inaccurate messages.	Briefing community precautions prior to an evacuation.
Equipment	Nil	Nil
Governance	Difficulties in establishing environmental health involvement in recovery	Trucking in safe drinking water rather than using unsafe reticulated water.
	Volunteers without training handling hazardous items such as asbestos.	Monitoring the donation of food safety at evacuation centres.
	Food products being transferred without temperature control.	If a task cannot be allocated, will become a responsibility for environmental health
Physical structure	Older people with no bed or food.	Nil
Power	No resupply of fuel for generators during a disaster.	Nil
	Generators running out fuel for people requiring oxygen.	
	Refrigeration and sewerage treatment plant issues.	
	Oxygen and dialysis patients require assistance during power outage.	
	Power outage resulting in respirators shutting down.	
Prevention	Nil	Nil
Sanitation	Immunocompromised people are susceptible to infections after a disaster.	Nil
	Diabetic cut foot cleaning up and then died due to infection.	

Services	Reduced access to medication and medical care. Lack of care can result in acute myocardial infarction or heart attack. For cancer patients a lack of care can result in their condition deteriorating. Lack of cleaning facilities. Asbestos clean-up issues in areas affected by tidal surge.	Nil
Supplies	People requiring oxygen and drugs often run out during a cyclone. Oxygen and medications can be almost non-existent after cyclones. Reduction in food supplies.	Nil
Surveillance	Nil	Nil
Transport	Reduced transport options for those requiring treatment and the elderly. Sold out of milk and bread due to road closures.	Distributing medication by helicopter. Floating medication across creeks.
Water	Poor water quality. Contaminated water going through reverse osmosis systems. Loss of safe water supply for compounding pharmacies and dialysis.	Nil
Workforce	Doctors burning out quickly.	Environmental health covering public health issues associated with disasters. Doctors and pharmacists staying to care for people. Establishing a strong environmental health network.
Other	No pets allowed in evacuation centres. People with pets would stay outside evacuation centres. Hard to convince farmers to evacuate when livestock is their cash flow.	Nil

4.2.3.3.1 Impact on public health infrastructure

The research found disasters impact on: communication; governance; physical structure; power, sanitation; services; supplies; transport; and water. For example, governance impacts included the difficulty in establishing environmental health involvement in recovery, food transferred without temperature control and volunteers handling hazardous items. Also, supplies can be impacted, which results in people running out of medications, transport options reduced, food shortages, poor water quality affecting reverse osmosis systems and compounding pharmacies. Other impacts included pets not being allowed in evacuation centres, people with pets staying outside evacuation centres and a difficulty in convincing farmers to evacuate when livestock is at risk.

4.2.3.3.2 Resilience strategies

The research found resilience strategies should be focused on communication, governance, supplies, transport and workforce. For example, communication could be enhanced through community briefings, particularly about the precautions required prior to an evacuation. Also, workforce strategies should include recognising that environmental health professionals are generally based in communities impacted.

4.2.3.4 Disaster impact by public health infrastructure and noncommunicable disease

Relationships were identified between NCDs and the PHI of: power; sanitation; services; supplies; transport; and water. The PHI not described as having a relationship with NCDs after disasters were: communication, equipment, governance, physical structure, surveillance and workforce. The reported impact of disasters by PHI and NCDs is provided in Table 4-3 and discussed in the following.

Table 4-3 Public health infrastructure descriptions

Theme	Descriptors similar with literature	Focus group descriptors (n=focus group; n=literature)
Communication	Information systems (sheets): social media; telephone.	Community meeting; community messaging; education/training; Facebook; information sheets; newspaper; police communication; social media; SMS; Twitter; telephone; radio; television (n=14; n=18).
Equipment	Beds (bedding).	Bedding; camp beds; cooking facilities; earthmoving equipment; mattress; trucks (n=7; n=9).
Governance	Command, control and coordination; disaster system; government.	Command, control and coordination; disaster plan; District Disaster Management Group; emergency; environmental health; evacuation; evacuation plans; exercising plan; Federal Government; food safety; legislation; Local Disaster Management Group; policies and procedures; private business; public health plan; State Government; sustained education programs (n=17; n=14).
Physical structure	Hospitals (health facilities); housing; shelters.	Accommodation; boating facilities; camps; caravan parks; churches; community hall; cyclone shelters; evacuation centres; food storage; hospitals; housing; licences premises/business; local council building; medical centre; PCYC; places of refuge; private home; schools; sewerage treatment plant; shelters; showgrounds; sports venue (n=23; n=16).
Power	Generators; power; power supply.	Back-up generators; fuel supply; generators; power; power supply (n=5; n=8).
Prevention	Prevention (of disease).	Disease control; prevention of disease (n=2; n=4).
Sanitation	Hygiene (personal); medical waste (management); sewage (systems); solid waste (collection); waste disposal (facilities); waste management; water treatment (plants).	Asbestos management; central washing area; clean-up of putrescibles; environmental health inspections of houses; landfill; medical waste management; personal hygiene; septic; sewage; sewerage supply; sewerage treatment; showers/bathe; solid waste; treatment; toilet paper; toilets; toothbrush; toothpaste; waste; waste disposal facilities; waste facilities; waste management; waste; water treatment plants; water purification; water sampling; water (n=27; n=14).

Services	Education (educating public); environmental health (inspections and assessments); food safety (inspections); healthcare (providers/program); health promotion; nursing homes; pharmacies.	Access to medication; asbestos clean-up; catering; childcare centre; cleaning services/facilities; community health centres; community-related services; dental services; doctors surgeries; doctors; educating public; environmental health inspections and assessments; food premises; food safety inspections; general practice; healthcare; health promotion; health-related services; inspecting septic systems; inspections of evacuation centres; licensed premises; medical care; medication dispensing; medication supply; medication; mobile morgues; morgues; mosquito control; mosquito response; nursing homes; oxygen; pharmacies; pharmacist; public and private hospitals; setting up evacuation centres (n=35;n=34).
Supplies	Food; food supply; fuel; medication(s); pharmaceuticals (supplies); water (sources)	Compounding pharmacies; drug supplies; first aid kits; food; food supplies; fuel for generators; fuel; medication; medical supplies; medication supply; oxygen supplies; pharmaceuticals; pharmacist; water (n=14; n=16).
Surveillance	Assessment; health data (data collection).	Damage assessment; statistics on status of food premises; data collection; health records; personal information; public health data; surveys of evacuation centres prior to activation; understanding disease priorities (n=8; n=6).
Transport	Aircraft/airport; roads; road/transport network; transportation.	Access to laboratory services; access to waste landfill; aircraft; delivering drugs; evacuation; floating medication; helicopter; logistics; road network; roads; transport network; transport; transportation; trucks (n=14; n=9).
Water	Dams/reservoir; water supply.	Reservoir; town water supply; water bottles; water supply (n=4; n=4).
Workforce	Nurses; pharmacist; public health officials / environmental health officers.	Contractors; doctor at evacuation centre; doctors; electrical contractors; engineers; environmental health officers; nurses; pharmacist; volunteer groups (n=9; n=15).
Other	N/A	Animals (chickens) at evacuation centres; pet care; pound. (n=4)

4.2.3.4.1 Power

A power outage was reported to affect people with respiratory conditions, renal diseases and more generally those with NCDs who are reliant on power for treatment, care and services.

4.2.3.4.2 Prevention

If prior to a disaster NCDs, were poorly managed and there was a lack of planning (for example, no plans for accessing back-up inhalers for people with asthma), there was an increased risk of poor health outcomes.

4.2.3.4.3 Sanitation

The greatest impact of poor sanitation was for people with diabetes and asthma. The diabetes impact related a greater risk of infection during a clean-up. For people with asthma, increased mould growth could result in acute exacerbation. More generally, people with NCDs were immunocompromised making them vulnerable to infection.

4.2.3.4.4 Services

A loss of services resulted in interrupted treatment, care and services for people with cancer, cardiovascular diseases, diabetes, respiratory conditions and renal diseases. The impact on people with cancer related to a lack of services increasing the risk of acute care being required that was not available. For cardiovascular diseases, a lack of ongoing care increased the risk of myocardial infarction or heart attack. Respiratory and renal conditions were at risk because these patients require help during a power outage. The general impact was due to treatment, care and services programs often falling by the wayside during disasters.

4.2.3.4.5 Supplies

The greatest impact of supplies failing was on people with respiratory conditions. This was due to generators for oxygen and respiratory equipment running out of fuel. More generally for people with NCDs there was a lack of medication and inadequate food supplies placed people with food allergies at risk.

4.2.3.4.6 Transport

When a disaster impacted transport, there was a reduction in access to treatment, care and services, fresh produce and supplies

4.2.3.4.7 Water

The impact of disasters on water had the greatest risk for people with renal diseases. The result was a loss of safe water for dialysis treatment.

4.2.3.5 Mitigation strategies

The mitigation strategies were categorised into the PHI themes of: communication; governance; prevention; services; surveillance; and workforce. Within each theme and a potential role for environmental health was identified. A description of the mitigation strategies is at Table 4-4 and discussed in the following.

Table 4-4 Mitigation strategies

Public Health Infrastructure (Theme)		Role for environmental health?
Communication	Accessible training	Yes
	Clinicians discussing preparedness with patients	No – clinician led
	Communication that meets community needs	Yes
	Communication to the disaster coordination centre	Yes
	Educating patients to be self-sufficient	No – clinician led
	Educating people before, during and after a disaster	Yes
	Short message service (SMS) warnings; Facebook; Twitter; radio; television; newspaper	Yes
	Two-way communication	Yes
Equipment	Nil	N/A
Governance	Clear understanding of roles and responsibilities	Yes
	Coordination	Yes
	Community based plans	Yes
	Federal government; state government, private businesses and partnership with jurisdictions	Yes
	Hospital disaster plans	Yes
	Interagency planning	Yes
	Plan for people with noncommunicable diseases (NCD) who cannot self-medicate at home	Yes
	Testing plan	Yes
Physical structure	Nil	N/A
Power	Nil	N/A
Prevention	Individual planning	No – clinician led
	People with NCDs have redundancies in-place	No – clinician led
	Empower people to take care of their own health	No – clinician led

	Sustained education and training campaigns	Yes
	Capacity building	Yes
	Community resilience	Yes
Sanitation	Nil	
Services	Doctor at evacuation centre	Yes – combined with clinicians
	Maintaining chronic disease management	Yes – combined with clinicians
Supplies	Nil	
Surveillance	Central registration point	Yes
	Register of dialysis patients	Yes
	Surveys of evacuation centres prior to activation	Yes
	Understand community needs	Yes
	Vulnerable people list	Yes
Transport	Nil	N/A
Water	Nil	N/A
Workforce	Training in environmental health	Yes
Other	Nil	N/A

4.2.3.5.1 Communication

Communication could be used to discuss preparedness individually with people who have NCDs and more broadly the community. For effective communication, multiple methods should be used including newspaper, radio, social media and television. It was important communication educated people to be self-sufficient and was clearly linked with the local disaster coordination system. Any direct communication with patients should be led and guided by clinicians.

4.2.3.5.2 Governance

Establishing and maintaining governance structures would help to mitigate the impact of disasters on people with NCDs. This should include: ensuring government and non-government organisations had a clear understanding of roles and responsibilities; working in partnership across jurisdictions; and community based plans. Hospital and interagency planning was required along with the testing of plans for people with NCDs, particularly people who cannot self-medicate at home.

4.2.3.5.3 Prevention

Prevention can be a mitigation strategy by empowering people to take care of their own health. This can include individual planning, sustained education, and training campaigns.

4.2.3.5.4 Services

Targeted services, such as basing doctors at evacuation centres to maintain treatment, were identified as strategies to help mitigate the impact of disasters on people with NCDs.

4.2.3.5.5 Surveillance

By establishing and maintaining surveillance, the impact of disasters on people with NCDs can be reduced. This could be achieved by having central registration points for people with NCDs and maintaining registers of people at risk. Rapid and regular surveys of evacuation centres and other infrastructure could be used to understand community needs before, during and after a disaster.

4.2.4 *Discussion*

To effectively reduce the risk disasters post to people with NCDs, it is critical for the environmental health profession to be part of interdisciplinary solutions. This is particularly important because the work of the profession interweaves across various disciplines and stakeholders.[61] For example, safe water is important for clinicians overseeing dialysis treatment. Achieving this will require working collaboratively with individuals, the community, government and other entities to truly achieve the best outcome for people with NCDs. To implement this approach a number of strategies are recommended:

4.2.4.1 Environmental health expanding disaster related activities to include NCDs

This change could be easily achieved by building on existing roles in the disaster setting, which includes monitoring and assessing public health risks before, during and after a disaster. To achieve this, an authentic trespassing of professional boundaries is required. This, for example, would include a team of integrative expertise: clinicians, engineers and environmental health professionals working together to prepare for and respond to disasters.[62]

The first step to achieve this would be for a global leader in environmental health and disaster management, such as the International Federation of Environmental Health and National Environmental Health Association, to actively seek involvement in developing local, national and international strategies to address the challenges faced by NCDs. Achieving this would reflect the emerging risks, diversity and intensity of recent disasters and show a sign of maturity within environmental health and disaster management systems.[63] Most importantly, the result would be a credible step towards improved health outcomes for people with NCDs before, during and after a disaster.

The potential for the profession to achieve this expansion is highlighted by the Sendai Framework. Statement 30(k) states that chronic diseases (NCDs) need to be included in the design of disaster policies and plans.[13] Specific environmental health measures may include interweaving and crosscutting disaster strategies such as protecting equipment/infrastructure, mapping vulnerabilities within a community and helping stockpile medicines.[6,61,64,65] This would help ensure people with NCDs have ongoing and/or rapid access to life-saving services during and after disasters.[13]

4.2.4.2 Targeted mitigation strategies

The reported impact of disasters on people with NCDs demonstrates the need for mitigation strategies to be targeted towards specific PHI. There should be a focus on maintaining communication, governance, power, prevention, sanitation, services, supplies, transport, water and the workforce. For example, communication could be enhanced through community briefings, particularly about the precautions required prior to an evacuation. Also, workforce strategies should recognise that environmental health professionals are generally based in the communities impacted and are responsible for creating and maintaining environments which promote good health.[66]

The relationships identified between the impact of disasters on PHI and NCDs in Table 4-5 further demonstrates the need for a targeted approach. For example, there are relationships between NCDs and the PHI of: power; sanitation; services; supplies; transport; and water. By focusing on this PHI, the environmental health profession would need to be engaged as part of the interdisciplinary solution.

Table 4-5 Reported impact of disasters by public health infrastructure and noncommunicable disease

Public Health Infrastructure	Cancer	Cardiovascular	Diabetes	Respiratory	Renal Diseases	NCD-General
Communication						
Equipment						
Governance						
Physical structure						
Power				Oxygen patients require help during power outage; generators for oxygen and respiratory equipment running out of fuel.	Dialysis patients require help during power outage.	Generators being used inside resulting in carbon monoxide poisoning.
Prevention						If NCDs are poorly managed prior, there is an increased risk of poor outcomes after a disaster.
Sanitation			Diabetic cut foot cleaning and then died due to infection.	Asthma reactions from exposure to mold after a flood.		Immunocompromised are susceptible to infections after a disaster.

Services	Lack of services can result in cancer patients requiring acute care that is not available.	Lack of ongoing care increases risk of acute myocardial infarction or heart attack.	Oxygen patients require help during power outage; asbestos exposure due to inadequate clean-up.	Dialysis patients require help during power outage.	Chronic disease management programs fall by the wayside during emergencies.
Supplies			Generators for oxygen and respiratory equipment running out of fuel; little to no fuel resupply for generators during a disaster.		Lack of medication; people requiring drugs often run out of supplies; medications can be almost non-existent after cyclones; people with food allergies are at risk if inadequate food.
Surveillance					
Transport					Reduced transport options for people requiring treatment and the elderly.
Water				Loss of safe water supply for dialysis; contaminated water in reverse osmosis systems.	
Workforce					
Other					

4.2.4.3 Research to measure and monitor progress and effectiveness

Further research is required to measure whether the recommended mitigation strategies, including expanding the role of environmental health and an interdisciplinary approach, makes a difference to maximising treatment, care and services for people with NCDs. This should be guided by the major NCDs identified by WHO (cancer, cardiovascular, chronic respiratory and diabetes) and the relationship with PHI identified in this paper.[6]

Finally, to properly address the risks that disasters pose to the health of people with NCDs, clinicians, engineers, government, and non-government agencies need to truly understand how the environmental health profession can assist. This is because the challenges posed by NCDs encompass a range of disciplines and this includes the core elements of the environmental health profession. Although this research has provided a useful basis for this change to occur, there is a need for ongoing workshops, dialogue and training on this issue at local, national and international levels. This would better define the role of environmental health and help implement strategies to maintain treatment management and care for people with NCDs. Ultimately, achieving this will help implement the Sendia Framework and, most importantly, assist in protecting the health and wellbeing of people with NCDs before, during and after a disaster.

4.2.5 *Limitations*

The research was influenced by the lead author's studies and work in public health and disaster management in Australia at local, state and national levels and across the Asia-Pacific. To address this, the data was checked by the second author and the results reviewed by all authors.

The research was limited to cyclone, flood and storm related disasters in Australia. This is because these events account for 75% of all disasters and 80% of disaster related economic losses in Australia.[67] Extreme heat and wild fire are other well-known and significant hazards/risks in Australia.[68,69] However, their long-term impact on PHI such as access to healthcare, healthy food and clean water is minimal when compared to flood, cyclone and storm related disasters.[68,69]

A focus on regional and rural areas in the state of Queensland, Australia, could be considered a limitation. However, this state and the selected locations have experienced the majority of large scale and devastating natural disasters in recent years, including cyclones, damaging storms and far reaching floods.[70,71] For example, Severe Tropical Cyclone Larry (2006), Severe Tropical Cyclone Yasi (2011), Tropical Cyclone Ita (2014), Tropical Cyclone Marcia (2015), and flash flooding in the Lockyer Valley towns of Withcott, Grantham and Gatton (2011), flooding in Brisbane/Ipswich (2011) and Bundaberg (2013).[72] For this reason, it is proposed the findings can be transferred to the same disaster types across the world where there are similar disease burdens/trends.

Another potential limitation is transferability of the findings outside high-income country settings. The research was limited to a high-income country setting and caution should be taken in applying the results to low and middle-income countries as the NCD priorities may change.

4.2.6 *Conclusion*

Environmental health professionals are not only well placed to help reduce the impact of disasters on people with NCDs, but an essential resource in better understanding and mitigating the problem. The profession needs to be part of the interdisciplinary solution to this challenge. Environmental health professionals are often employed in communities where disasters occur and the core elements of their work are indirectly linked to maximising treatment, care and services for people with NCDs. Disasters impact on power, sanitation, services, supplies, transport and water, which increases the risk of treatment, management and care for people with NCDs being interrupted. The result is an increased risk of a severe exacerbation of existing illness or even death. An expansion of focus to include NCDs is a new concept for the profession. By recognising, defining and implementing this potential, government and non-government agencies would be better placed to implement the Sendai Framework. Most importantly, the result would be a significant step towards helping protect the health of people with NCDs before, during and after a disaster.

4.3 Disaster service provider perspective on public health infrastructure and noncommunicable disease management

Published – Ryan BJ, Franklin RC, Burkle Jr FM, Aitken P, Smith E, Watt K and Leggat, P (2016). Reducing Disaster Exacerbated Non-Communicable Diseases Through Public Health Infrastructure Resilience: Perspectives of Australian Disaster Service Providers. PLOS Currents Disasters. Dec 21, 2016, Edition 1. Impact factor not available; Indexing PubMed and Scopus; Google Scholar citations 15 – Appendix E.

4.3.1 *Introduction*

Extreme weather-related disasters are becoming increasingly frequent, due largely to a sustained rise in intensity, severity and frequency of floods and storms (including cyclones, hurricanes, typhoons and tornadoes).[7-11,73] For example, flooding accounted for 47% of all weather-related disasters from 1995 to 2015, affecting 2.3 billion people, with storms (less frequent) having the highest mortality.[73] During this period the exposure of the population and infrastructure to weather-related disasters across the world has also increased.[7,13]

The bulk of ill health, disability and premature death around the globe now generates from noncommunicable diseases (NCD).[21,74] A combination of population aging, increasing obesity, decreasing physical activity, environmental change and a reduction in communicable diseases has contributed to this epidemiological transition to NCDs.[1,6,10,16,17,19,75] However, the traditional focus of the disaster response has been on the management of immediate trauma and communicable diseases.[10] This focus remains despite the actual risk of post disaster communicable disease outbreaks being low, particularly in developed countries.[1,6,15,72] This highlights the need to refocus disaster risk reduction strategies and resources to the most vulnerable populations.[6-12]

The high-burden of NCDs presents a challenge for disaster and health systems, especially when public health infrastructure (PHI) is destroyed, inaccessible or damaged. In this situation treatment, care and services is often jeopardised, which can result in disease exacerbation or even death.[1,6,10,19,22-27] People with NCDs at greatest risk are those with underlying cardiovascular and respiratory diseases, undergoing cancer treatment, unstable diabetes and

renal diseases.[6,19,23,33,76-79] PHI priorities in the disaster setting include: workforce; water; sanitation; equipment; communication; physical structure; power; governance; prevention; supplies; service; transport; and surveillance.[59] All mentioned is vital for maximising treatment, care and services for people with NCDs and must be properly maintained.[3,16,80]

The challenge of NCDs has been recognised in the *Sendai Framework for Disaster Risk Reduction 2015-2030* (Sendai Framework), which is complementary to and building on the World Health Organization (WHO) *Global Action Plan for the Prevention and Control of Noncommunicable Diseases – 2013-2020*.[81] NCDs should be part of policy design and implementation of plans to manage risks before, during and after disasters, including having access to life-saving services.[13,82]

Despite this recognised challenge, research on the strategies required to implement the Sendia Framework and address the impact of disasters on people with NCDs are scarce. This is a significant risk for people in the state of Queensland, Australia. Queensland has recently experienced a number of large scale and devastating natural disasters including cyclones, damaging storms and far reaching floods, and has a high burden of NCDs.[70,71] The disasters have included: Severe Tropical Cyclone Larry (2006); flash flooding in the Lockyer Valley (2011); and Severe Tropical Cyclone Yasi (2011).[72] Also, NCDs cause approximately 90% of all deaths, account for 88% of the burden of disease and are responsible for 83% of recurrent health expenditure in Queensland.[34,83] The burden of NCDs, although lower at 78%, is also a major concern for Indigenous people with these conditions being responsible for 80% of the mortality gap (69.1 years for males, 10.6 years lower than non-Indigenous; 73.7 years for females, 9.5 years lower than non-Indigenous).[84,85] The threat of natural disasters for vulnerable populations with NCDs is expected to continue and is anticipated to increase, with climate change expected to make extreme weather events such as cyclones and floods more frequent.[70,86]

This paper is part of a project aiming to develop strategies for reducing disaster exacerbated NCDs through PHI resilience.[1,6,10,87] Specifically, this study focuses on the perspective of responders, coordinators and government officials designated as disaster service providers. In the wider project, different approaches have been used to gather information around NCDs and PHI resilience. Participant groupings include: environmental health professionals (via focus groups)[1]; disaster service providers (via interviews and a focus group); and people with NCDs

(via interviews). Combining these groups into one research paper would have greatly missed the individual challenges, nuances and recommendations from being understood and placed on each group. Each group has a unique, discrete and important perspective, for example, the environmental health profession addresses risks relate to drinking water, sanitation, food safety and mass gatherings.[3,4] Disaster service providers are responsible for overall leadership, designing and managing system-wide preparation, prevention, response and recovery phases of disaster management.[5] Meanwhile, people with NCDs represent the group at greatest risk of disease exacerbation if impacted by a disaster.[6]

The aim of this research was to explore the role of disaster service providers in reducing disaster exacerbated NCDs through PHI resilience. To achieve this, interviews and a focus group were conducted with disaster service providers in the State of Queensland, Australia. This included: investigating descriptions of PHI from their perspective; the impact of disasters on PHI, and proposed resilience strategies; disaster impact by PHI, and NCD; and identification of mitigation strategies by PHI.

4.3.2 *Methods*

Data was collected via 32 interviews and one focus group (eight participants) between March 2014 and August 2015 with 40 disaster service providers representing ten organisations. The qualitative analysis included the phases of: organising data; data description; and data classification and interpretation.[46,47,88] A description of the research area, definitions and the analysis process are provided in the following.

4.3.2.1 Research area

The research areas included: Cairns and Hinterland Hospital and Health Service (HHS); Darling Downs HHS; Townsville Hospital and Health Services HHS. All are located in the State of Queensland, Australia. Government officials with disaster management responsibilities in Brisbane (State Capital) were also included as their decisions directly influence PHI, management of NCDs and disaster responses.

The focus on Cairns and Hinterland HHS, Darling Downs HHS and Townsville HHSs was due to their NCD burden and recent disasters.[89,90] For example, Severe Tropical Cyclone Larry (2006), flash flooding in the Lockyer Valley (2011); and Severe Tropical Cyclone Yasi (2011),

which resulted in widespread damage to PHI.[72] Natural disasters are a feature of the climate and landscape in these regions and are anticipated to increase, with climate change expected to make extreme weather events such as floods and storms more frequent.[70,72,86]

The Cairns and Hinterland HHS services a population of just over 280,000. Of this population, 9% are Indigenous, compared to 3.5% for Queensland and 2.5% for Australia.[90,91] The Darling Downs HHS services a population just under 280,000 and Indigenous people make up 4.2 per cent of the population.[92] The Townsville HHS services a population of approximately 240,000 and 7% are Indigenous.[93] There are no demographics for Brisbane because this is primarily the location of government officials who influence PHI, management of NCDs and disaster responses from a state-wide perspective.

4.3.2.2 Definitions:

4.3.2.2.1 Disaster service providers

The experiences of three types of disaster service providers were explored: responders, coordinators and government officials. These disaster service providers were invited to participate because their perceptions, experience and knowledge are vital in influencing strategies for reducing disaster exacerbated NCDs through PHI resilience. A description of each group is provided below:

- Responder: This group includes doctors, nurses, paramedics, police officers and representatives from non-government organisations such as the Australian Diabetes Educators Association, Australian Red Cross and the Kidney Support Network. Discussions with this group addressed the preparedness, prevention, response and recovery arrangements and the role of various individuals, organisations and leading local players in disaster health management.[5]

- Coordinator: This group includes local disaster coordinators, members of Local and District Disaster Management Group's and disaster management officers from Queensland Fire and Emergency Services. This group provides a conduit between Local and State Disaster Management Group's groups and has specialist knowledge of the principles of disaster management.[5]

- Government officials: This group includes representatives from the Department of Health (Queensland), Queensland Police Service, Queensland Fire and Emergency Services and Queensland Ambulance Service who had a state-wide disaster management role. This group was based in the State Capital of Queensland, Australia (Brisbane). Overall this group is responsible for leading, designing and managing the state-wide preparation, prevention, response and recovery phases of disaster management.[5]

4.3.2.2.2 Noncommunicable disease (NCD)

The NCD terms used to guide the analysis were cancer, cardiovascular diseases, diabetes, respiratory conditions and renal diseases.[6] These conditions are at greatest risk of exacerbation after a disaster and are long-lasting and place great burden on patients, health services and fiscal systems.[83,94] A category of NCD-general was used for additional conditions identified by participants.

4.3.2.2.3 Public health infrastructure (PHI)

PHI and the associated services were considered the workforce, equipment, supplies, and services required to maintain the health and wellbeing of individuals and the community.[87] Beyond this definition, there were 13 PHI themes used to guide the analysis and (in priority order) included: workforce; water; sanitation; equipment; communication; physical structure; power; governance; prevention; supplies; service; transport; and surveillance.[87]

4.3.2.2.4 Resilience

Resilience is the capacity to prevent, mitigate, prepare for, respond to, and recover from the impacts of disasters.[70,95] In this context resilience focuses on enhancing the ability of PHI to minimise the effects of future disaster events on people with NCDs. Resilience is a dynamic quality and is usually developed and strengthened over time, it builds upon rather than replaces existing strengths and arrangements.[95]

4.3.2.3 Data collection

Data was collected through interviews and focus groups, which were guided by a combination of structured and open-ended questions developed by the research team. The aim of the data collection phase was to understand the role disaster service providers could have in maximising

the treatment, care and services for people with NCDs during and after a disaster. The questions focused on participant's examples of PHI; relationship between a breakdown of PHI, and poor health outcomes for people with NCDs; and mitigation strategies.

The participants were recruited and selected using a purposive sampling strategy.[46] A focus group was held in Townsville and interviews conducted in Brisbane, Cairns and Innisfail (Cairns and Hinterland HHS), Townsville (Townsville HHS) and Toowoomba (Darling Downs HHS).

The principle of saturation was used to determine the number of interviews.[46,47,96,97] For convenience a focus group was held in Townsville as part of a regional disaster meeting. The point of saturation was achieved after approximately 25 interviews. The focus group and remaining six interviews did not generate any new information. The additional interviews were held to ensure all organisations and research locations had an opportunity to participate.

4.3.2.4 Data Analysis

A deductive content analysis was used to analyse the data for both the interviews and focus groups. This included the phases of: organising data; data description; and data classification and interpretation.[46,47,88] The process is described in the following:

1. Organising data: the focus group and interviews were tape recorded and then transcribed. After transcription the data was saved electronically and then uploaded to QSR NVivo 10.
2. Data description: A description of the data was developed based on the key phrases, ideas and concepts. Interview participants were allocated a de-identified code, for example, *I1*, and focus group data was referred to as *FG*. Firstly, "lean coding" was used to analyse the data. The terms were based on the descriptions of PHI, and NCDs; mitigation strategies; and negative, positive and neutral impact of flood and storm related disasters on PHI, and NCDs. Secondly, the codes were placed in a Microsoft Excel™ spreadsheet to develop an individual description based on the key phrases, ideas and concepts.
3. Data classification and interpretation: The data was classified through an aggregation of individual descriptions and themes in a Microsoft Excel™

spreadsheet to create an overall case description. The data was analysed by comparing PHI descriptors with the literature, describing NCD descriptors, outlining the impact of disasters on PHI and resilience strategies, reporting the impact by PHI and NCD, and demonstrating mitigation strategies by PHI theme. The data was then interpreted in the discussion to understand the role of disaster service providers in mitigating the impact of disasters on treatment, care and services for people with NCDs.

4.3.2.5 Ethics

Ethics approval was provided by James Cook University (H4871), Australia, and Townsville Hospital and Health Service Human Research Ethics Committee (HREC/13/QTHS/251). Site specific ethics approval was received from the Cairns and Hinterland HHS (SSA/15/QCH/54 – Lead 147), Darling Downs HHS (SSA/14/QTDD/21) and the Townsville HHS (SSA/14/QTHS/153). This was complemented by letters to specific agencies and disaster management groups seeking permission to invite staff to participate in the research.

4.3.3 *Results*

4.3.3.1 Participants

The majority of the participants were responders (40%; n=16) followed by coordinators (35%; n=14) and government officials (25%; n=10) (Table 4-6). There were 17 female and 23 male participants. The majority of participants were from agencies in Brisbane (38%; n=15) followed by the Townsville HHS (33%; n=13), Cairns and Hinterland HHS (20%; n=8) and Darling Downs HHS (10%; n=4). Of the Brisbane based participants, n=5 were categorised as responders as they worked for non-government agencies.

Table 4-6 Demographics for disaster service providers

Demographic		**Responder**		**Coordinator**		**Government Official**	
		Interview	**Focus Group**	**Interview**	**Focus Group**	**Interview**	**Focus Group**
Participants		14	2	10	4	8	2
Gender		9 Female; 5 Male	1 Female: 1 Male	3 Female; 7 Male	1 Female; 3 Male	3 Female; 5 Male	2 Male
Location	Cairns and Hinterland HHS	4	-	4	-	-	-
	Darling Downs HHS	3	-	1	-	-	-
	Townsville HHS	2	2	5	4	-	2
	Brisbane	5*	-	-	-	8	-
Disaster experience by type	Cyclone	3	-	1	3	-	1
	Cyclone and flood	3	-	3	-	8	1
	Cyclone and tornado	2	2	-	1	-	-
	Cyclone, flood and fire	-	-	2	-	-	-
	Cyclone, flood and tornado	1	-	1	-	1	-
	Flood	6	-	-	-	-	-
	Flood and fire	-	-	1	-	-	-
Organisation type	Local Government	-	-	1	-	-	-
	State Government	7	2	7	4	8	-

Federal Government	-	-	2	-	-	2
Non-government Organisation	7	-	N/A	-	-	-

* These participants were from non-government organisations

All participants had responded to a natural disaster and were in some way involved in disaster management. Most had experienced multiple disaster types with cyclone and flood the most common (13%; n=15) followed by cyclone and tornado (13%; n=5); cyclone, flood and fire (5%; n=2); cyclone, flood and tornado (5%; n=2); and flood and fire (3%; n=1). The most common single type of disaster experience was cyclone (20%; n=8) followed by a flood (15%; n=6).

The majority of participants were from State Government agencies (75%; n=30). This included 40% (n=16) from the Department of Health and HHSs followed by 22% (n=9) from the Queensland Police Service, and 10% (n=4) Queensland Ambulance Service and Queensland Fire and Emergency Service. Other participants were from non-government organisations (18%; n=7), Australian Government (5%; n=2) and Local Government (3%; n=1).

4.3.3.2 Public health infrastructure descriptors

The interviews and focus group identified 130 different descriptors of PHI, which were grouped into 14 themes (Table 4-7). In comparison, Ryan et al (2016)[87] identified 167 different descriptors for PHI, which were grouped into 13 themes. The disaster service providers identified more descriptors for prevention and water. Meanwhile, the literature identified more descriptors for all other themes. An additional theme of "Other" was identified by the participants. This was used to group pets which according to the participants should be considered a descriptor for PHI. Additional descriptors were identified by the participants for all thematic areas except power.

Table 4-7 Descriptions of public health infrastructure, disaster service providers

PHI	Descriptors similar to the literature	Additional disaster service provider descriptors	Number of descriptors	
			Disaster service provider	Literature[30]
Communication	Communication; media (social); phone lines (telephone); public messaging (information sharing).	Advertising; public health campaigns; video conference.	7	18
Equipment	Day dialysis beds (beds); equipment; medical devices; personal devices (medical devices); refrigerator; sharps (needles and syringes).	Charges; hygiene packs; microwave.	9	9
Governance	Disaster management system (disaster system); hospital system; law enforcement (food safety); leadership.	District disaster management group; health system; local disaster management group; non-government agencies; planning; preparation; privacy; state government.	12	14
Physical structure	Buildings; health service buildings (hospital infrastructure); hospital; homes; medical facilities; shelter; storage for medication (storage facilities).	Aged-care home; community health facilities; evacuation centre; sewage treatment plant; water treatments plant.	12	16

Power	Electricity; generators; power; solar power.	Nil.	4	8
Prevention	Health promotion (promotion); prevention of disease (prevention).	Balanced diet; heat protection; hydration; removing mosquito breeding grounds; sun protection; vaccination programme.	8	4
Sanitation	Personal hygiene (hygiene); infection control; sanitation; sewage; waste management.	Hygienic clinical areas; street-cleaning.	7	14
Services	Ambulance (ambulance service); clinics; diagnostic care (diagnosis); emergency services (emergency medical services); healthcare services (hospital care); medical centres (medical services); nursing homes; pharmacies; vaccination (vaccine programs).	Chemotherapy; clinical follow-up; clinical waste management; community facilities; dialysis; effluent disposal; health response; immunisation clinics; nursing homes; oncology services; pathology services; prescribing medicine; primary healthcare; refuse removal; sewage treatment; vector control; water treatment.	26	34
Supplies	Food; gas; medication; medicine; nutritious food; prescription medication (prescription drugs); supplies.	Clothing; condoms; diesel; oxygen; water supplies.	12	16
Surveillance	Assessments; health data.	Contact tracing; asbestos mapping; flood-mapping.	5	6
Transport	Bridge; roads; transport; transportation.	Driveways; logistic/transport routes; road access; transit.	8	9

Water	Drinking water; water supply (reticulated).	Bottled water; chlorine levels; clean water; safe water; water systems.	8	4
Workforce	Doctors (general practitioners and medical personnel) environmental health professionals (officers); nurses (community nurses); public health workforce (public health personnel); staff; trained staff (health professionals).	Administrative personnel; aeronautical medical staff; people conducting assessments; technicians.	11	15
Other	Nil	Pets.	1	0
		Total	130	167

4.3.3.3 Disasters impact on public health infrastructure and proposed resilience strategies

The participants described various impacts of disasters on PHI (n=56) and proposed resilience strategies (n=37), which were categorised into two descriptors (reported impact and proposed resilience strategy). The descriptions were categorised into PHI themes outlined in Table 4-8 and are discussed below.

Table 4-8 Disaster impact on public health infrastructure – proposed resilience strategies

Theme	Reported impact	Proposed resilience strategies
Communication	1. Breakdown results in people losing touch with the health system. 2. Damaged systems can result in delivery of unsuitable equipment. 3. Communications can be out for ten days or longer. 4. Damaged communication can limit access to transport for treatment, care and services. 5. Difficult to re-engage and communicate with patients after disaster.	1. Patients encouraged to develop treatment plans post disaster. 2. Targeted communication plans, particularly for home based patients. 3. Easy access to call centre/central information service. 4. Regular communication about health service status. 5. Ongoing advertising on the need for individuals to be prepared.
Equipment	6. Dialysis equipment can become unusable due to flooding. 7. Insulin pumps, needles and syringes can become damaged and contaminated. 8. Medical equipment can be unusable due to a loss of power.	6. Patients have access to replacement medical equipment. 7. Patients have plans to maintain refrigeration of medication. 8. Refrigeration available at evacuation centres.

Governance	9. Damaged governance can impact support for the response and recovery. 10. Disaster planning is required at the individual level. 11. If there are no alternate health service plans, treatment can be jeopardised. 12. The time required for accurate weather predictions results in evacuation delays. 13. Vulnerable people often stay in-place because of limited support for evacuation.	9. Embed media in disaster management groups. 10. Identify people at risk and providing sufficient supplies prior to disaster. 11. Individual planning and preparation. 12. Targeted planning for people with NCDs.
Physical structure	14. Damaged housing can result in patients relocating without health service knowledge. 15. Damaged treatment infrastructure can prevent access to medical treatment.	13. Design and locate infrastructure so treatment can be maintained. 14. Evacuations centres have power for medical equipment. 15. Safe storage for medication.
Power	16. A loss of power can impact on the operation of medical equipment. 17. Drinking water can become contaminated. 18. Home phones can fail preventing people with NCDs from calling for assistance. 19. Hygiene standards can be compromised due to power outage. 20. Increased reliance on the health system by home based patients. 21. Power outage can impact food supply. 22. Refrigerator failure can impact on medication storage.	16. Back-up power sources for home based patients and health facilities. 17. Plans to ensure medicines maintained under temperature control. 18. Storage of back-up fuel for generators.
Prevention	23. A lack of individual preparation results in poor health outcomes.	19. Treatment plans for patients.

Sanitation	24. Food safety issues. 25. Increased risk of infection for dialysis patients. 26. Poor hygiene can impact on people who are immunocompromised.	20. Plans to maximise access to clean water and safe food. 21. Plans to provide a hygienic environment for immunocompromised people.
Services	27. Emergency Departments tend to be full. 28. General practitioners tend to either be full or closed. 29. If hospital services are unavailable people often go to evacuation centres. 30. Impact on treatment plans. 31. Limited access to technicians for repairing medical equipment. 32. Patients requiring health services can be cut off and unable to be evacuated. 33. Reduced access to equipment. 34. Reduced follow-up on treatment, care and services 35. Visiting health services can be cut off.	22. Plans to provide health services at multiple sites. 23. Disaster management groups supporting medication management. 24. Plans to use aircraft and telehealth to provide health services.

Supplies	36. Communities resupply cut off. 37. Damage to pharmacies reducing access to medication. 38. Interruption to supply of medications. 39. Lost medication. 40. Medical supply shortages. 41. Patients often forget to bring medication to evacuation centres. 42. Patients running out of medication. 43. Reduced access to healthy food. 44. Supply sources for medication and equipment can be damaged. 45. Unable to access accessories for medical equipment.	25. Patients bring medication to evacuation centres. 26. Access to healthy foods at evacuation centres. 27. Alternative supply chains for medicines and equipment. 28. Safe water supply. 29. Refrigeration at evacuation centres for medication. 30. Storage and distribution of hygiene packs including medications.
Surveillance	46. Knowledge of people at risk.	31. Mapping of people at risk by noncommunicable disease. 32. Mechanism for sharing information between agencies.
Transport	47. A loss of transport can prevent people from accessing treatment, care and services. 48. Limited access to taxis. 49. No transport, which can result in supplies such as medication being exhausted. 50. Patients in outlying areas can be cut off preventing access to hospitals.	33. Alternate transport options such as boats and helicopters. 34. Evacuation of high-risk people prior to disaster.

Water	51. Contamination of water can impact on hygiene standards. 52. Drinking water can become contaminated. 53. Unsafe water can compromise medical equipment such as dialysis machines.	35. Access to bottled water.
Workforce	54. Delays in support services attending sites impacted. 55. Reduced follow-up on patients. 56. The local workforce is impacted resulting in staff shortages.	36. Staff trained in disaster management systems. 37. Agency wide rapid response systems.

4.3.3.3.1 Impact on public health infrastructure (PHI)

The participants reported flood and storm related disasters can impact all aspects of PHI. Damage to communication, equipment, power, services and supplies can result in people losing touch with the health system, limiting access to treatment and patients running out of medications. Governance, transport and workforce is often interrupted or overwhelmed, which can impact on the response and recovery, reduce access to treatment, result in some vulnerable people not being evacuated due to a reduction in support resources. Damage to physical structure, sanitation and water can prevent access to treatment, compromise medical equipment and result in poor hygiene standards, and increase the risk of infection. An interruption of surveillance reduces the knowledge-base about people at risk, making it difficult to properly target resources. Post disaster, any inadequacies in prevention activities such as poor town planning, inadequate stockpiling/storage of medications and lack of individual preparedness by with people with NCDs becomes evident. The result is interrupted treatment, care and services and an increased risk of poor health outcomes for people with NCDs.

4.3.3.3.2 Resilience strategies

The participants described resilience strategies for all phases of the disaster cycle impacting on PHI. For communication, equipment, services and supplies this included encouraging targeted communication, use of telehealth, patients having their own treatment plans post disaster, providing access to back-up medical equipment and plans to provide health services at alternate

sites. Governance, transport, workforce and surveillance strategies could include embedding media in disaster management groups, targeted planning for people with NCDs, use of alternate transport options, early evacuation and agency-wide staff training. Physical infrastructure and sanitation could involve designing and locating infrastructure to allow treatment to be maintained and plans to maintain a safe water supply. Resilience for power could include evacuation centres having the capability to power medical equipment and back-up power sources for home based patients and health facilities. Water supply could become resilient by ensuring access to bottled water.

4.3.3.4 Reported impact of disaster by public health infrastructure and noncommunicable disease

The participants reported relationships between the impact of a disaster on PHI, and increased health risks for people with NCDs. These relationships are outlined in Table 4-9 and discussed in the following.

Table 4-9 Descriptions of public health infrastructure, disaster service providers

Public health infrastructure theme	Descriptors similar to the literature	Additional disaster service provider descriptors	Number of descriptors	
			Disaster service provider	Literature[30]
Communication	Communication; media (social); phone lines (telephone); public messaging (information sharing).	Advertising; public health campaigns; video conference.	7	18
Equipment	Day dialysis beds (beds); equipment; medical devices; personal devices (medical devices); refrigerator; sharps (needles and syringes).	Charges; hygiene packs; microwave.	9	9
Governance	Disaster management system (disaster system); hospital system; law enforcement (food safety); leadership.	District disaster management group; health system; local disaster management group; non-government agencies; planning; preparation; privacy; state government.	12	14
Physical structure	Buildings; health service buildings (hospital infrastructure); hospital; homes; medical facilities; shelter; storage for medication (storage facilities).	Aged-care home; community health facilities; evacuation centre; sewage treatment plant; water treatments plant.	12	16
Power	Electricity; generators; power; solar power.	Nil.	4	8
Prevention	Health promotion (promotion); prevention of disease (prevention).	Balanced diet; heat protection; hydration; removing mosquito breeding grounds; sun protection; vaccination programme.	8	4
Sanitation	Personal hygiene (hygiene); infection control; sanitation; sewage; waste management.	Hygienic clinical areas; street-cleaning.	7	14

Services	Ambulance (ambulance service); clinics; diagnostic care (diagnosis); emergency services (emergency medical services); healthcare services (hospital care); medical centres (medical services); nursing homes; pharmacies; vaccination (vaccine programs).	Chemotherapy; clinical follow-up; clinical waste management; community facilities; dialysis; effluent disposal; health response; immunisation clinics; nursing homes; oncology services; pathology services; prescribing medicine; primary healthcare; refuse removal; sewage treatment; vector control; water treatment.	26	34
Supplies	Food; gas; medication; medicine; nutritious food; prescription medication (prescription drugs); supplies.	Clothing; condoms; diesel; oxygen; water supplies.	12	16
Surveillance	Assessments; health data.	Contact tracing; asbestos mapping; flood-mapping.	5	6
Transport	Bridge; roads; transport; transportation.	Driveways; logistic/transport routes; road access; transit.	8	9
Water	Drinking water; water supply (reticulated).	Bottled water; chlorine levels; clean water; safe water; water systems.	8	4
Workforce	Doctors (general practitioners and medical personnel) environmental health professionals (officers); nurses (community nurses); public health workforce (public health personnel); staff; trained staff (health professionals).	Administrative personnel; aeronautical medical staff; people conducting assessments; technicians.	11	15
Other	Nil	Pets.	1	0
		Total	130	167

4.3.3.4.1 Communication

Disrupted communication was reported to impact on people with cardiovascular, diabetes, renal diseases and more generally those with NCDs. The cardiovascular and diabetes impacts relate to a loss in communication preventing access to medication. For people with renal diseases, the risk is predominately for home based patients because damage to phone lines can make it difficult to check if the patient is dialysing. More generally, communication breakdown after a disaster can result in patients being *"…dropped out of the health system…they can't access health services…we lose them, they're very hard to re-engage…(I31)"*.

4.3.3.4.2 Equipment

Equipment damage or interruption can impact people with diabetes, renal diseases and more generally those with NCDs. For people with diabetes equipment can become lost or damaged. Dialysis machines and associated equipment can become contaminated. For example, *"…the machine will clog up…there's a potential risk of losing the blood in your lines, some stuff leaking through and coming into your blood system, because the machine is not working at 100%...(I3)"*. Also, medical equipment can become unusable for long-periods, particularly due to a reduction in access to technicians and other resources required for repair work.

4.3.3.4.3 Governance

An interruption to governance can impact on the health of people with NCDs, particularly if there is inadequate planning by agencies and individuals. For example, there are *"…plenty of examples of people with noncommunicable diseases needing assistance in shortened timeframes which could have been avoided if they had…that planning and preparation…in place…(I1)"*. Another concern was that *"…people who are at home they tend to be our biggest problem within the district level and the local level… There's no lists and no collective storage of information on these particular people…(FG)"*.

4.3.3.4.4 Physical structure

Damage to physical structure can impact on the health of people with cancer, renal diseases and more generally NCDs. For people with cancer, curative treatment can become compromised, for example, if *"…someone is in the middle of a curative treatment…you need to be able to have*

infrastructures to maintain treatment…(I27)". Renal patients also require *"…shelter, food, clothing, health and hygiene packs…(I4)*". More generally, the result is reduced access to treatment, care and services.

4.3.3.4.5 Power

An interruption to power can affect people with diabetes, respiratory conditions, renal diseases and more generally those with NCDs. A power outage can impact on refrigeration of insulin for people with diabetes. For people with respiratory and renal diseases there can be a reduction in access to treatment and life-sustaining equipment. Also, for people with respiratory conditions it can result in an increased reliance on the ambulance service, which can have a negative impact on the entire health system. For example, *"…they lose the power; that then impacts on them; their families, ourselves as the ambulance service, because then we've got to either try to supply some oxygen to them in the short term; take them to hospital which then impacts on the hospital's ability to respond to significant events in an emergency department…(I32)"*. A power outage can also impact on communication, preventing calls for assistance.

4.3.3.4.6 Prevention

Inadequate prevention activities can affect people with diabetes and more generally those with NCDs. Inadequate preparedness by patients can result in uncontrolled diabetes. For example, they *"…tend to have a lot of phone calls mainly in the form of uncontrolled blood sugar… a lot of them will tell you that they lost the paper or the medication…(I26)"*. More generally, a lack of individual preparation for a disaster results in poor health outcomes post disaster.

4.3.3.4.7 Sanitation

Damage to sanitation can impact on people with cancer and renal diseases. Poor hygiene can impact the health of people undergoing cancer treatment, for example, *"…when people are on chemotherapy and if their immune system is down…need to make sure that the water quality is good"*. Also, for people with renal diseases "*…there's lots of elements that hygiene's really essential… I think about their water quality; I think about their exchange areas. Is it clean and hygienic?...(I27)"*. The risk is greatest for transplant patients and those undergoing dialysis treatments.

4.3.3.4.8 Services

A lack of services can impact people with cancer, cardiovascular, diabetes, respiratory conditions, renal diseases and more generally NCDs. Interrupted access to services and medication can compromise the heath of people with cancer, cardiovascular, diabetes, respiratory conditions and renal diseases. For example, *"...we also had a visiting oncology service. We didn't actually have a medical oncologist who was located here at Toowoomba Hospital so they were cut off from us...(I7)"*. More generally, follow-up care for people with NCDs can be reduced because patients impacted by a disaster can lose access to treatment and then move without advising the health service.

4.3.3.4.9 Supplies

Damage to supplies can impact on people with cancer, cardiovascular, diabetes, respiratory conditions, renal diseases and more generally NCDs. For people with cancer this risk relates to unsafe food and medical supply shortages. If medication is not available, people with cardiovascular conditions are at an increased risk of a cardiac arrest, diabetes can become uncontrolled and the overall health of renal transplant patients is at risk. For people with respiratory diseases this can result in an increased reliance on the ambulance service and hospitals to maintain treatment, care and services. More generally people with NCDs often forget medication when evacuated. For example, *"...if it increases the stress on that person, then there's no doubt it could well have an impact if they have heart disease or cancer or any other condition...(I12)"*.

4.3.3.4.10 Surveillance

Disruption to surveillance can indirectly impact on people with a range of NCDs. For example, *"...there's a lot of people who do stay at home, who, in fact, may not have been impacted, like their house is okay, but they still might be isolated because of flood roads, so they're the ones we don't know anything about...(I24)"*. Another situation was described where there was *"...no database...(I27)"* to determine *"...how many...patients are home-oxygen dependent or home-dialysis dependent...(I27)"*. The result is an inability to proactively allocate the resources required to help people most at risk of disease exacerbation.

4.3.3.4.11 Transport

Damage to transport can impact on people with cancer, cardiovascular, respiratory, renal diseases and more generally NCDs. For example, *"...patients from all outlying areas were cut off from…services here at…Hospital…(I7)"*. Also, *"transport mechanisms to get them from home to the treatment facilities, because the majority don't have vehicles…(FG)"*. Overall, the loss of transport reduces access for people with NCDs to services, medication supply and acute medical care.

4.3.3.4.12 Water

Disrupted water supply can impact on people with cancer, renal diseases and more generally NCDs. Unsafe water can compromise the health of people with cancer and the medical equipment used to treat people with renal diseases. For example, *"The water systems…have a huge impact on the dialysing machines that filter the water…(I3)"* and if not filtered correctly *"…stuff in the water could get into the patient's blood…(I8)"*. Overall, for people with NCDs there can be an increased risk of infection and communicable diseases due to unsafe water reducing hygiene standards.

4.3.3.4.13 Workforce

An interruption to the workforce can impact on people with diabetes, renal diseases and more generally NCDs. For example, *"…our biggest thing was staffing…getting staff…(I30)"*. For people with diabetes, a reduction in the workforce can prevent access to specialist advice. For example, after a recent cyclone *"…we had lots of phone calls from patients that they've had high blood glucose levels, unwell, or distressed because they've lost their power, wanting to know how to store medications…(I20)"*. A reduction in staff at dialysis centres can compromise treatment of home based patients who need rapid access to an alternate treatment facility. More generally, a reduction in staff can reduce follow-up on patients.

4.3.3.4.14 Other

Respondents were aware of cases where people dependent on oxygen (respiratory assistance machines) often do not evacuate due to their pets, even if their supply is running low.

4.3.3.5 Mitigation strategies

Participants described 72 strategies for mitigating the impact of disasters on treatment, care and services for people with NCDs. The strategies have been categorised by PHI, service and participant group in Table 4-10.

Table 4-10 Mitigation strategies by public health infrastructure – responsible area

Public health infrastructure	Strategy	Disaster service provider category		
		Responder	Coordinator	Government Official
Communication	1. Access to telemedicine, telephone, SMS, e-mail or radio after a disaster	x	x	x
	2. Annual community-wide day of readiness for disasters	x		
	3. Brochures for NCDs at cyclone shelters and evacuation centres			x
	4. Central contact point for people with NCDs	x		
	5. Clinically led planning for patients	x		
	6. Communicate where people with NCDs can go after a disaster	x		
	7. Encourage patients to take personal responsibility		x	x
	8. Encouraging patients to have a list of emergency contacts	x		
	9. Information about preparedness in utility notices			x
	10. Ongoing advertising on the need for individuals to be prepared	x	x	x
	11. Provide a disaster pack with steps to follow	x		
	12. Regular communication about health service status	x		

	13. Targeted communication plans			x
Equipment	14. Patients have access to replacement medical equipment			x
	15. Patients have plans to maintain refrigeration of medication	x		x
	16. Storage of back-up medication in a secure location	x		
	17. Waterproof treatment, care and services kits	x		
Governance	18. Alternative plans for places to maintain treatment, care and services	x		
	19. Centralised and coordinated transport to access treatment, care and services	x		x
	20. Close working relationship between public and private facilities			x
	21. Contact details for local health professionals are readily accessible	x		
	22. Embed media in disaster management groups			x
	23. Health representation at disaster management groups	x	x	
	24. Identify people at risk and provide sufficient supplies prior to disaster		x	x
	25. Individual planning and preparation	x	x	x
	26. Legislation to allow sharing of treatment needs between agencies	x		x
	27. Local disaster groups coordinate communication around preparedness	x	x	
	28. Messaging about assisting people with medical issues after a disaster	x		
	29. Monitoring and communicating access to health services	x		

	30. Planning to ensure adequate medical stock and supplies	x		x
	31. Plans in-place to resume services immediately after a disaster			x
	32. Preplanning with medical suppliers		x	x
	33. Preregistration of people with NCDs	x	x	
	34. State-wide clinical network to coordinate patient treatment, care and services	x		
	35. State-wide understanding local public health infrastructure priorities		x	
	36. Storing supplies prior to cyclone season	x	x	
	37. Streamlining processes for patients to access medication and treatment	x		x
Physical structure	38. Evacuation centres have power for medical equipment			x
	39. Hubs for treatment, care and services after a disaster	x		x
	40. Disaster resilient health infrastructure		x	x
	41. Safe storage for medication	x		x
Power	42. Back-up power for people reliant on medical equipment		x	x
	43. Charging devices for medical equipment at evacuation centres			x
	44. General Practitioner (GP) surgeries having back-up power	x	x	
	45. Storage of back-up fuel for generators	x		x
Prevention	46. Health care providers reducing reliance on hospital system	x		
	47. Emergency treatment kits for people with NCDs	x	x	x
	48. GP work with patients to develop disaster plans			x

	49. Health professionals trained to use telemedicine	x		
	50. People with NCDs understanding their vulnerabilities	x	x	x
	51. Systems in-place to allow people to return home after evacuation			x
	52. Town planning to reduce vulnerability of health services to a disaster			x
Sanitation	53. Maximise access to clean water and safe food for people with NCDs	x	x	x
	54. Provide a hygienic environment for immunocompromised people	x		x
Service	55. Health professionals visit evacuation centres and other mass gathering	x		x
	56. Plans to provide health services at multiple sites		x	
	57. Rapidly bring extra healthcare personal into a community			x
	58. Use telehealth to provide access to health services	x		
Supplies	59. Alternative supply chains for medicines and equipment		x	
	60. Surplus equipment and medication for disaster season	x	x	x
	61. Patients bring medication to evacuation centres	x		x
Surveillance	62. Mapping of people at risk by NCD	x	x	x
	63. Mechanism for sharing information between agencies	x	x	x
Transport	64. Multiple transport options such as boats and helicopters	x	x	x
	65. Evacuation of high-risk people prior to disaster			x

Water	66. Evacuation of people reliant on safe water for treatment			x
Workforce	67. Interagency rapid response systems	x	x	x
	68. Clinicians encourage patients to discuss disaster planning with family	x		x
	69. Clinicians work with patients to understand disaster options and needs	x		
	70. Health professionals provide remote telemedicine care after disaster	x		
	71. Health professionals actively contacting patients after a disaster	x		x
	72. Staff trained in disaster management systems	x		x

Mitigation strategies were described for all phases of the disaster cycle. For communication, governance, services and the workforce this could include: use of telemedicine, providing brochures at shelters, regular communication about the health service status, close working relationship between public and private sectors, preplanning with medical suppliers, effective town planning, health professionals visiting evacuation centres, and staff trained in disaster management systems. Equipment, physical structure, power, supplies, transport and water strategies include: storage of back-up medication and equipment in secure locations, evacuation centres having power for medical equipment, hubs for treatment, care and services after a disaster, general practitioner surgeries having back-up power, alternate supply chains, and evacuation of high risk people prior to disaster. Prevention, sanitation and surveillance would include: emergency treatment kits for people with NCDs, people with NCDs understanding their vulnerabilities, providing a hygienic environment, mapping people at risk by NCD, and a mechanism for sharing information between agencies.

The responder group suggested the highest number of mitigation strategies followed by government officials and coordinators. Responders identified 19 unique mitigation strategies, government officials 15 and coordinators three. There were 14 mitigation strategies identified by both responders and government officials. Responders and coordinators identified five similar mitigation strategies. The coordinator and government official groups identified five similar strategies. There were 11 mitigation strategies identified by all groups.

All groups identified mitigation strategies within the PHI categories of communication, governance, prevention, sanitation, supplies, surveillance (described in next paragraph), transport and workforce. Communication related to the need for ongoing advertising on the need for individuals to be prepared and this was complimented by governance where individual planning and preparation is required. From a prevention perspective all groups recommended emergency treatment kits are provided for people with NCDs and for sanitation access to clean water and safe food needs to be maximised. Supplies relate to ensuring a surplus of equipment and medication for the disaster season. For transport multiple options, such as boats and helicopters, are required and this would support the workforce strategy of ensuring interagency rapid response systems were in-place.

Two surveillance strategies were recommended by all groups. These included mapping and the sharing of information about people with NCDs. For example, *"...GPs forwarding through...to the Local Disaster Management Group a list of their patients that they believe to be at risk, so that perhaps we can plan to manage those at-risk patients prior to the event rather than wait until after the event...(I27)".* Another consideration is *"...having a map almost, or an indicator that we've got...dialysis patients and these are their addresses. And then you can then work out what you need to from there. This person can last 24 hours without dialysis or two days or two hours...(I6)".* A common theme from the participants was that having accurate and easily accessible data on people with NCDs would allow disaster service providers to adequately prepare for and respond to a disaster.

4.3.4 *Discussion*

Disaster service providers are best placed to lead implementation of strategies for reducing the impact of disasters on people with NCDs. This is because their activities cut across the entire spectrum of the disaster system, including with government, non-government and private sectors. They are employed in communities where disasters occur and the core elements of their work are directly linked to enhancing PHI resilience. Specific measures include: increasing the use of telemedicine, preplanning with medical suppliers, effective town planning, health professionals visiting evacuation centres, evacuation centres having power for medical equipment, hubs for treatment, care and services after a disaster, evacuation of high risk people prior to disaster, mapping people at risk by NCD, and a mechanism for sharing information between agencies.

Within the disaster service provider group, responders are best placed to lead and guide implementation of the mitigation strategies. For example, the *"...local system needs to feed into the hierarchy of command and the patient should only be having contact with that local person...(I4)"*. This could only occur with support from coordinators and government officials. The importance of responders leading this work is further supported by the high number of mitigation strategies recommended by this group, which reflects their work 'on the ground' before, during and after disasters. Meanwhile, the coordinator group provides the much-needed conduit between responders and government officials.

Disaster service providers consider themselves responsible for maximising treatment, care and services for people with NCDs. For example, a situation was described where *"...we knew the bridge was going to go under, so we ensured that the people that needed medication were identified in that township and we ensured that they had their medications, because they were going to be isolated...(I9)*". This combined with the wide range of disciplines among disaster service providers demonstrates they can provide the leadership required to systematically expand the focus of disaster systems to include NCDs. To guide implementation of this change PHI, services and NCD considerations are discussed in the following along with implementation of the mitigation strategies.

4.3.4.1 Public health infrastructure (PHI) considerations

A relationship was identified between damage to PHI and an increased risk of disaster exacerbated NCDs. This concern is consistent with the literature which has found that when PHI are destroyed or rendered inaccessible access to chronic care treatment and medication is jeopardised.[19, 55] Also, acute care can also become compromised and this presents a risk for people with NCDs, for example, orthopaedic surgery is at much higher risk when a patient has poorly controlled cardiovascular disease.[98]

An interruption to transport will not only decrease access to services but reduce the ability to provide care. To overcome this risk, strategies need to be in-place to allow the disaster service providers to provide care and treatment during and immediately after a disaster.[87] This could include disaster and health planners encouraging those who provide care to have personal disaster plans. This proposal compliments other research which has found the willingness of nursing staff to attend a workplace after a disaster increases by eight times if they have a disaster plan.[99] Also,

people are more likely to attend work after a disaster if their colleagues are prepared for disaster response.[100]

Pets should be considered part of PHI. For example, people *"...won't leave because of their pets...(I10)"* even if *"...their oxygen was running really low...(I10)"*. There is also the risk that people with pets will not attend evacuation centres and there can be difficulty in convincing farmers to evacuate when livestock is at risk.[1] For this reason, when developing plans it is important disaster and health planners consider how pets will be handled.

The identification of additional descriptors for the PHI themes identified by Ryan et al[87] is another step towards describing and categorising PHI priorities for disaster management systems. The next step is a validation of the PHI themes, descriptors and priorities. The result would be a clearer understanding of PHI before, during, and after a disaster. This information will be vital to systematically inform preparation, response, and recovery activities and plans for reducing the risk of disaster exacerbated NCDs through PHI resilience.

4.3.4.2 Noncommunicable disease (NCD) considerations

The level of attention given to disaster risk reduction activities in mitigating NCDs needs to be accelerated, particularly due to global population aging, increasing obesity and overweight and decreasing physical activity.[16,17,19,75] The challenge will be to broaden the focus of disaster management activities for health from response and recovery within the disaster cycle model to a more proactive approach which emphasizes prevention and mitigation.[101] For example, participants described an option that*"...I don't think there's very good pre-planning for an event in relation to those people that do have chronic diseases...(I32)"*. Addressing this will require the health system to increase capacities and relationships across community, non-government, government and service provider sectors (including electricity and telephone companies).[101] The Sendai Framework statement concerning chronic diseases (NCDs) provides the platform for this to occur.[13]

Another consideration beyond the NCDs targeted by this research is the impact disasters may have on drug users and people in drug addiction treatment programs. Research participants discussed the need to consider the impact a breakdown of services or supplies may have on people reliant on methadone and other treatments for drug addiction. Also, evacuation centres and shelters are often ill equipped to address acute drug withdrawals and maintain specialised services for treatment

programs.[102] The result is an over reliance on emergency room dosing that lead to unsafe or suboptimal dosing.[103] This issue could be addressed by developing guidance to rapidly verify identification, establish proof of treatment and ascertaining dosage information.[102] By recognising this challenge, strategies can be developed to ensure drug users and people in drug addiction treatment programs receive the care needed.

4.3.4.3 Mitigation strategies – implementation

The mitigation strategies presented provide the theoretical basis required for demonstrating how PHI resilience can maximise the treatment, care and services available for people with NCDs before, during and after a disaster. Although the responder group proposed more strategies than the governmental officials and providers, it is the entire set of strategies that provides the theoretical basis for addressing the problem. The mitigation strategies are interrelated via PHI because if one component fails the health and wellbeing of people with NCDs will be compromised.

To sustainably implement the mitigation strategies, they will need to become integrated into effective performance and monitoring of the disaster response and health sector during non-disaster periods. For this to occur, the strategies should be integrated into business and strategic plans. This could include, for example, identifying a disaster resilient location for back-up treatment, care and services and working with primary health care facilities to design a hub model of care post disaster. This approach would ensure PHI disaster resilience, and the benefits this will have for the ongoing care of people with NCDs, is integrated into system-wide policies, plans, programmes and budgets.[13]

While sharing of information across agencies about people with NCDs has been identified as a strategy there are ethical and community willingness considerations. For example, in Australia vulnerable persons registers (generally include people with NCDs) are maintained at the local government level and registration is voluntary.[104] The result is often an underestimate of the number of people at risk, for example, in the State of Victoria, Australia, there are less than 1,350 registered as vulnerable out of a population of just under six million.[105,106] To help address this problem, it is recommended an integrated system be developed that allows local healthcare providers to provide and update information on patients they believe are vulnerable to disaster managers at local government levels. This would occur with permission from the patient.

A collaborative governance approach is required to implement the mitigation strategies due to the wide range of disciplines, organisations and sectors involved.[14] Such an approach would be an amalgamation of organisations beyond the current disaster management system (government agency focus) to allow community and private organisations such as universities, primary health care sector (general practitioners and pharmacies) and transport companies to help solve this problem.[107] The process would include: engaging in comprehensive and shared planning; formal communication across multiple levels; and pooling and jointly acquiring resources to implement the mitigation strategies.[108] This approach would complement the comprehensive, all hazards, all agencies approach to disaster management in Queensland, Australia, and reflect the principles of intersectoral collaboration.[108-110]

To build on this research, further work is required to test the effectiveness of the proposed mitigation strategies. For example, does individual preparation actually makes a difference to health outcomes after a disaster? It would also be important to determine if the strategies made a difference by NCD, location and disaster type. The first step towards achieving this would be working with disaster service providers and people with NCDs to rank and prioritise the mitigation strategies. This would need to be followed by monitoring and evaluating disease trends before, during and after disasters.

Finally, the research has presented theoretical strategies for reducing the impact of disasters on the health and wellbeing of people with NCDs through PHI resilience. Further research needs to be completed to test the effectiveness of the strategies presented. For example, will strategies make a difference by NCD, location and disaster type. This would include working with disaster service providers, primary health care sector, community based organisations and people with NCDs to rank and prioritise the strategies. The result would be strategies which have clearly defined roles, responsibilities and options for enhancing PHI resilience. Ultimately, this will help implement the Sendai Framework and, most importantly, result in sustainable strategies that protect the health of people with NCDs before, during and after a disaster.

4.3.5 *Limitations*

The research direction was informed by the lead author's professional and research experience in the public health aspects of disasters in Australia at local, state and national levels and across the Asia-Pacific. The lead author has also been part of preparedness and response activities to cyclones

that have impacted some of the areas subject to the research. To address this limitation, the second author assisted with the research design and verified the data.

The research was limited to disaster service providers in Queensland, Australia, who have predominately prepared for, and responded to, cyclones, floods and storms in Australia. This group has a vital role in influencing the impact of disasters on PHI, which is vital for maximising treatment, care and services for people with NCDs. This type of role is similar in other parts for the world. For this reason, it is proposed the findings can be transferred to the same disaster types across the world where there are similar disease burdens/trends, however, caution is urged as all systems are unique.

Another potential limitation is that the research was limited to a high-income country setting. Therefore, caution should be taken to applying the findings to low and middle income countries, particularly as the PHI, services and NCD priorities and challenges may differ.

4.3.6 *Conclusion*

Disaster service providers can play a vital role in reducing the risk of disaster exacerbated NCDs through PHI resilience. They are often employed in communities where disasters occur and the core elements of their work are directly linked to enhancing PHI resilience to maximise treatment, care and services at a local level. This combined with the wide range of disciplines demonstrates they can provide the leadership required to systematically expand the focus of disaster systems to include NCDs. Specific measures include: increasing the use of telemedicine; preplanning with medical suppliers; effective town planning; health professionals visiting evacuation centres; evacuation centres having power for medical equipment; hubs for treatment, care and services after a disaster; evacuation of high risk people prior to disaster; mapping people at risk by NCD; and a mechanism for sharing information between agencies. To sustainably implement the mitigation strategies, they will need to become integrated into effective performance and monitoring of the disaster and health sectors during non-disaster periods. Achieving this will help implement the Sendai Framework and, most importantly, result in sustainable strategies that protect the health of people with NCDs before, during and after a disaster.

4.4 Perspectives of people with noncommunicable diseases on the role of public health infrastructure

4.4.1 *Introduction*

The increasing noncommunicable disease (NCD) burden and frequency of natural disasters across the world has created a need to address the risk of these conditions exacerbating post disaster.[6,19] Natural disasters can breakdown public health infrastructure (PHI) and ongoing protections, which reduces access to equipment, food, shelter, treatment and safe water.[6,10] The result is an increased risk of acute exacerbation of NCDs, worsening long-term prognosis and even death.[6,111] This threat is anticipated to continue, if not increase, due to a combination of climate change, deforestation and rapid urbanisation in flood plains and storm-prone coastal zones.[13,70,86,112] Also, over the past twenty years weather-related disasters have become increasingly frequent due largely to a sustained rise in the intensity and severity of floods and storms in urbanised areas.[73]

Research is now required that explores the perspectives of people with NCDs about what may exacerbate their condition post disaster and how this can be mitigated. This patient-centred approach is required to ensure the outcomes are meaningful for people with NCDs.[113] The people with NCDs at greatest risk of their condition exacerbating or even death post disaster are those with underlying cardiovascular and respiratory diseases, undergoing cancer treatment, with unstable diabetes, and with renal diseases, especially if receiving dialysis.[6] These conditions are also long-lasting and place great burden on patients, health services and fiscal systems.[34,94]

The risk disasters pose to people with NCDs has been recognised by the United Nations in the *Sendai Framework for Disaster Risk Reduction 2015-2030* (Sendai Framework).[13] The Sendai Framework is focused on managing risks (a shift from managing disasters), which requires a better understanding of risk in all its dimensions of vulnerability, exposure and hazards.[114] More specifically, item 30(k) of the Sendai Framework relates to chronic diseases (NCDs) and requests that people with life threatening conditions are included in the design of policies and plans to manage their risks before, during and after disasters.[13] This complements the World Health Organization (WHO) *Global Action Plan for the Prevention and Control of Noncommunicable Diseases – 2013-2020*.[81]

The Australian Diabetes Educators Association (ADEA) has built on the strong recommendation of the Sendai Framework as it relates to chronic diseases in its publication titled *The needs of people with chronic diseases in natural disasters – A guide for state and local governments, emergency management services and the not-for-profit sector*.[115] The issues post disaster affecting the health of people with cancer, cardiovascular diseases, diabetes, respiratory diseases and renal diseases are outlined along with the potential consequences. Strategies for reducing the risk of NCD exacerbation post disaster are also proposed but they were not informed by people with NCDs.

To sustainably address this problem, strategies must be informed by people with NCDs and align with the comprehensive all hazards and all agencies approach to disaster management.[70,116] This approach is particularly important in Australia because prevention, preparedness, response and recovery activities of the disaster cycle are delivered through collaborative partnerships with all agencies, organisations and communities.[70] This approach provides planners with a useful platform to ensure strategies can effectively reflect the recent epidemiological transition from communicable diseases to NCDs.[2]

This study is part of a broader project across the disaster management system that aims to reduce the risk of disaster exacerbated NCDs through PHI in Queensland, Australia.[1,6,10,87] A pilot study approach was selected to allow the researchers to pre-test or "try out", from a patient's perspective, if PHI could be used to mitigate the risk of NCD exacerbation after a natural disaster.[117] Furthermore, it provides the opportunity to validate theories and proposed strategies for solving this problem, which was identified in previous research.[1,2,6,10,87] This is a vital step before further development can begin on developing a framework for sustainably reducing the risk of NCD exacerbation post disaster.[118,119]

The aim of this study was to explore from a patient's perspective how PHI could be used to mitigate the risk of NCD exacerbation after a natural disaster. To achieve this, interviews were conducted with people who have NCDs in Queensland, Australia. This included exploring: the impact of disasters on PHI; the relationship between PHI breakdown after a disaster and NCD exacerbation; and mitigation strategies.

4.4.2 *Methods*

The data was collected via 11 semi-structured interviews with people who had a NCD between May 2014 and September 2015. The number of interviews was determined by the principle of saturation and this was reached after ten interviews.[46,47] Interview 11 did not generate any new information. A thematic analysis was undertaken and included the phases of: organising data; data description; and data classification and interpretation.[46,47,88] The research location, terms used for the research and description of the data analysis are described in the following.

4.4.2.1 Research location

The research occurred within the geographical areas of the Cairns and Hinterland Hospital and Health Service (HHS), Darling Downs HHS and Townsville HHS in Queensland, Australia. These locations were selected due to the known NCD burden and recent disasters such as Severe Tropical Cyclone Larry (2006), flash flooding in the Lockyer Valley (2011); and Severe Tropical Cyclone Yasi (2011).[34,72,89] Also, climate change is expected to increase the frequency and intensity of natural disasters in these areas.[70,72,86]

The HHSs service a combined population of approximately 800,000 people. Of this 280,000 people are serviced by the Cairns and Hinterland HHS with 9% Indigenous Australians, compared to 3.5% for Queensland;[90] 280,000 people in the Darling Downs HHS with 4.2% Indigenous Australians;[92] and the Townsville HHS services approximately 240,000 people with 7% Indigenous Australians.[93]

4.4.2.2 Terms used for research:

4.4.2.2.1 Public health infrastructure (PHI)

The PHI definition was based on Ryan et al (2016, p.10) who defined it as "the workforce, equipment, supplies, and protection services required to maintain the health and wellbeing of individuals and the community".[87] The categories include: communication; equipment; governance; physical structure; power; prevention; sanitation; service; supplies; surveillance; transport; water; and workforce.

4.4.2.2.2 Noncommunicable disease (NCD)

The NCD conditions used to guide the analysis were cardiovascular diseases, cancers, chronic respiratory diseases, diabetes and renal conditions. These conditions are considered those most at risk of exacerbation after a disaster and account for the majority of the disease burden, healthcare costs and deaths across the world.[6,81,85]

4.4.2.3 Data collection

The data was collected through interviews, which were guided by a set of open ended questions focused on discussing and providing a better understanding of both the perceived objective and subjective impact of disasters on PHI; the relationship between PHI breakdown after a disaster and NCD exacerbation; and mitigation strategies.

Participants included people with cardiovascular diseases, cancers, chronic respiratory diseases, diabetes and renal conditions. People with these conditions were recruited through professional networks, NCD support organisations and the public domain. This included letters, e-mail and discussion with appropriate organisational representatives and public advertising was used, such as advertising notice boards at health care facilities and radio interviews.

The number of interviews was determined by the principle of saturation.[46,47] This was measured and monitored through ongoing evaluation of the data in comparison with the theories and proposed strategies from other research within the broader research project.[15, 16, 96, 27, 29, 32] Saturation was reached at interview 11, where there was no new information and a continuation of interviews would have made the pilot research repetitive and, eventually, superfluous.[96,97]

4.4.2.4 Data Analysis

A deductive content analysis method was used to analyse the data. This included: organising and managing data; data description; and data classification and interpretation.[46,47] This process is described in the following:

1. *Organising and managing data:* interviews were tape recorded and then transcribed. After transcription the data were saved electronically and then uploaded to QSR NVivo 10, which is software designed to organise and analyse qualitative data such as interviews.[120] The data was then organised into key phrases, ideas and concepts.

2. *Data description:* A description of the data was developed based on the key phrases, ideas and concepts. Interview participants were allocated a de-identified code, for example, *I1*. Firstly, "lean coding" was used to analyse the data.[46] The terms were based on the descriptions of PHI and NCDs; mitigation strategies; and impact of flood and storm related disasters on PHI and NCDs. Secondly, the codes were placed in a Microsoft Excel™ spreadsheet to develop an individual description based on the key phrases, ideas and concepts.

3. *Data classification and interpretation:* The data was classified through manual aggregation of individual descriptions and themes in a Microsoft Excel 2010™ spreadsheet to create an overall case description. QSR NVivo 10 was not used for this process because computer assisted systems are known to pose challenges in determining meaningful themes as they are not designed to synthesise data and interpret the meanings.[121] Ultimately, the quality of interpretation is determined by the rigor of the procedures employed by the researcher not the software. For these reasons the data was analysed manually according to the: impact of disasters on PHI; the relationship between PHI breakdown after a disaster and NCD risks; and mitigation strategies. The data was then interpreted to understand from the perspective of a person with a NCD how PHI could be used to reduce the risk of disaster exacerbated NCDs.

4.4.2.5 Ethics

Ethical approval was provided by James Cook University (H4871) and Townsville HHS Human Research Ethics Committee (HREC/13/QTHS/251). Site specific approval was provided by Cairns and Hinterland HHS (SSA/15/QCH/54 – Lead 147), Darling Downs HHS (SSA/14/QTDD/21) and Townsville HHS (SSA/14/QTHS/153). This was complemented by letters to non-governmental agencies seeking permission to invite members with NCDs to participate in the research.

4.4.3 *Results*

4.4.3.1 Participants

There were seven female and four male participants (Table 4-11). The majority of participants had been impacted by a disaster (72%; n=8). Two had experienced both a cyclone and flood, and three each a cyclone or flood. Two participants had multiple NCDs, one had cancer and cardiovascular

disease and the other cancer and renal disease. The most common NCD was cancer (39%; n=5) followed by renal conditions (23%; n=3), diabetes (15%; n=2), cardiovascular (15%; n=2) and respiratory conditions (8%; n=1). The Cairns and Hinterland HHS had the majority of participants (54%; n=6) followed by the Darling Downs HHS (36%; n=4) and Townsville HHS (9%; n=1).

Table 4-11 Demographics

Demographic		Diabetes	Cancer	Cardio-vascular diseases	Renal diseases	Respiratory diseases
Noncommunicable disease*		2	4	2	4	1
Gender		2 Female	3 Female; 1 Male	1 Male	1 Female; 2 Male	1 Female
Location	Cairns and Hinterland HHS	1	2	1	1	1
	Darling Downs HHS	0	2	0	2	0
	Townsville HHS	1	0	0	0	0
Disaster experience	Cyclone	0	1	1	1	0
	Flood	2	1	0	0	0
	Cyclone and flood	0	1	0	0	1

***** Two participants had multiple noncommunicable diseases: cancer and cardiovascular disease; and cancer and renal disease. Both identified cancer as their primary condition.

4.4.3.2 Reported impact on public health infrastructure

The participants reported various impacts of disasters on PHI (n=26). The impacts were categorised by PHI theme and are outlined in Table 4-12 and discussed below.

Table 4-12 Impact of disaster on public health infrastructure, people with NCDs

Public Health Infrastructure	Reported impact
Communication	Communication systems are not available.
	No access to priority care and services.
	Limited health warnings and information about the situation.
	Loss of contact with healthcare team.
	Damage to communication systems can impact on advice about continuation of care.
Equipment	Damage to refrigeration.
Governance	Nil.
Physical structure	Shelters can become crowded and not appropriate for vulnerable people.
Power	Loss of climate control.
	Power outage can impact phones, particularly mobile phone batteries.
	Loss of refrigeration.
Prevention	Nil.
Sanitation	Nil.
Services	Disrupted treatment, care and services.
	Reduced access to health services.
	Services overwhelmed.
Supplies	Pharmacy supplies of insulin can run out.
	Nutritious food supplies can become exhausted.
	Unable to access medications.
	Food supplies exhausted.
Surveillance	Nil
Transport	Airport can be closed.
	Transportation to the doctor compromised.
	Road access blocked.
	Driveway access blocked.

	Limited access to taxis.
	No transport.
	Patients in outlying areas can be cut off.
Water	Nil.
Workforce	Reduced access to diabetic educators, general practitioners and specialists.
	Reduced follow-up on patients.

4.4.3.2.1 Communication

A disruption to communication can result in limited health warnings, loss of contact with a healthcare team and reduced access to information about continuation of care plans. For example, *"…as far as the phones, if they're out, then I would be in real trouble because I wouldn't be able to contact them…(I3)"*. Also *"… how could I get out to feed myself? Who would help me if I did become ill?...(I10)"*.

4.4.3.2.2 Equipment

Equipment, including home appliances, such as refrigerators can become damaged and result in a loss of medication. For example *"…lack of access to refrigeration, particularly at very hot times would be a concern …(I7)"*.

4.4.3.2.3 Physical structure

Physical structure, such as shelters, can become overcrowded and potentially provide inappropriate care for people with NCDs. For example, shelters would *"…be very crowded, and for an old lady with my circumstances, full of arthritis and I'm on a walker, and I have other things wrong with me, cancer and so forth, it would be an imposition to go out to one of those shelters…(I10)"*.

4.4.3.2.4 Power

Power disruption can impact phone use and compromise treatment. For example, *"…you know, to have dialysis, but, you know, the power could possibly be out…this place was, you know, inundated by a tsunami or something, then it would be -- it would be a big problem…(I9)"*.

4.4.3.2.5 Service

Service interruption can reduce access to pharmacies, health professionals and medical care. For example, *"...For people…on dialysis…if that were interrupted due to a disaster that would have a very serious impact on people with those conditions…(I7)"*. Also, *"...the big concern there is that any disruption of this nature negatively effects on your treatment…it negatively effects on your ultimate outcome…(I8)"*.

4.4.3.2.6 Supplies

The provision of, and access to, supplies can be disrupted and result in food and medication running out. For example, *"...the first things that I had issue with…was getting food, and also getting medication…(I6)"*.

4.4.3.2.7 Transport

Interruption to transport mechanisms and infrastructure such as airports, roads, taxis and blocked driveways can prevent access to health care and accommodation. For example, *"...my biggest concern is that something like a flood where you get cut off…(I7)"*. Also, *"...In terms of accommodation and things like that, if you can't get back down the mountain, what happens…(I1)"*.

4.4.3.2.8 Workforce

A disruption to the workforce can result in reduced treatment, care (non-medical intervention) and patient follow-up. For example, *"...reduced access to the GP and specialist…(I11)"*.

4.4.3.3 Public health infrastructure and noncommunicable disease disaster risks

Relationships were reported between a breakdown in communication, equipment, governance, physical structure, power, services, supplies, transport and workforce and an increased risk of NCD exacerbation. This relationship is demonstrated in Table 4-13 and discussed by PHI theme in the following.

Table 4-13 Impact by public health infrastructure and noncommunicable disease

Public health infrastructure	Cancer	Cardiovascular	Diabetes	Respiratory	Renal diseases	NCD-general
Communication		Loss of communication can prevent access to medication.	Loss of communication can prevent access to medication.		Phone outage can prevent home-based patients from accessing medication and services.	Communication breakdown can result in patients losing touch with healthcare system.
Equipment			Insulin pumps and syringes contaminated, lost and damaged.		Dialysis machines and equipment contaminated.	Medical equipment unusable due power loss and/or contamination.
Governance						Poor planning reduces time for assistance; if no alternate plans, treatment, care and services will be jeopardised.

Physical structure	If infrastructure is not resilient, people undergoing treatment may be at risk.			Renal patients require shelter, food, clothing, health and hygiene packs.	Patients often forget to bring medication to evacuation centres; infrastructure used to provide treatment can become damaged; damaged housing can result in patients relocating without health service knowledge; damaged pharmacies reduce access to medication.
Power		A loss of power impacts on refrigeration of insulin.	Oxygen concentrators require power; lost power results in increased reliance on ambulance service and hospitals.	Lost power impacts on dialysis machines, particularly home based;	If back-up power sources fail, treatment, care and services is jeopardised; increased reliance on the health system by home based patients; home phones fail preventing calls for assistance.
Prevention		Inadequate preparedness by patients can result in uncontrolled diabetes.			Lack of individual preparation results in poor health outcomes.

Sanitation	Poor hygiene impacts on the health of people undergoing treatment.				Transplant patients are susceptible to poor sanitation; dialysis patients at increased risk of infection.	
Services	Interrupted access to services; reduced access to acute services is a risk.	Loss of ongoing care increases risk of heart issue; reduced access to medication.	Loss of acute medical care for uncontrollable diabetes.	Reduced access acute medical care.	Interrupted access to dialysis; technician services reduced.	Patients requiring health services cut off and unable to be evacuated; reduced follow-up; lack of acute medical care.
Supplies	Health compromised by consuming unsafe food; medical supply shortages.	Increased risk of cardiac arrest if no medication; medication forgotten when evacuated; medication supply interrupted.	Lack of medication increases risk of uncontrolled diabetes; limited access to nutritious food; lost access to medical accessories and supplies.	If oxygen supplies run out patients end up at hospital; increased reliance on ambulance service to supply oxygen or evacuate patients.	Medication supply reduced (transplant) patients at greatest risk.	Patients run out of medication; interruption to medication supply; community resupply cut off.
Surveillance						Limits knowledge of people at risk and their location.

Transport	Prevents specialists travelling to areas cut-off; reduced access to treatment.	Damaged transport reduces medication supply.	Medications supply reduced due to being cut-off; loss of access to acute medical care.		Transport interruption prevents access to hospitals, particularly for home based patients; if not evacuated early, creates challenges for emergency services.	Loss of transport results in medication being exhausted; patients cut off preventing access to treatment; supplies from other locations not provided.
Water	Health compromised by unsafe water.				Can compromise medical equipment; safe water helps ensure sanitary conditions; increased pressure on dialysis centres due to interrupted home-based treatment.	Increased communicable disease risk; unsafe water compromises treatment, care and services; contaminated water impacts on hygiene standards.
Workforce			Adequate resources required to answer phone calls from patients.		Dialysis centres and hospitals require staff to accommodate influx of home based patients.	Local workforce often impacted resulting in staff shortages; Reduced staff results in limited follow-up on patients.
Other				People often do not leave due to their pets, even if oxygen is running low.		

4.4.3.3.1 Communication

A breakdown in communication can impact on people with cancer and diabetes due to patients becoming unaware of plans for continuation of services, patients reliant on health team based treatment not receiving the care required and inadequate messaging. For example, *"…we weren't told, you know, what was going to happen with our treatment; what -- if there were any continuation plans…(I8)"*. For *"…diabetics who come from a background of a more sort of health team-based management…communication would definitely be an issue…(I7)"*. Concerns were raised about health warnings not being tailored to the needs of people with existing conditions, for example, *"…now…they do…warnings -- advices before a disaster. They're just tailored for the general public…(I6)"*.

4.4.3.3.2 Equipment

Damage to equipment can impact on people with diabetes and other NCDs due to a loss of refrigeration storage for medication. For example, *"...something like fridges going out would affect not just your diabetic, it would affect pharmacies, hospitals, everyone who is storing that kind of thing…(I7)"*.

4.4.3.3.3 Governance

A disruption to governance can result in patients losing access to key contacts and becoming unaware of locations for accessing treatment, care and services. This can also create additional stress for patients. For example, *"...to relieve stress...it's knowing; it's having the information present, so knowing that there are plans; knowing...what you do. These are the phone numbers. These are who you would contact…(I8)"*.

4.4.3.3.4 Physical structure

Damage to physical structure can result in patients being relocated to a shelter where the conditions are not appropriate for people with NCDs and/or places patients with impaired immunity to a secondary infection. A participant stated, *"... I have...cancer and so forth, it would be an imposition to go out to one of those shelters…(I8)"*. Also, *"...what would be worse than an incontinent person in a crowded shelter with children...and everybody…(I10)"*.

4.4.3.3.5 Power

A power disruption can impact people with diabetes, dialysis and other NCDs due to a loss of phone access and compromised indoor climate control. For example, people who *"...spend a lot more time in contact with their healthcare team...in disaster situations where, you know, electricity might be out and that kind of thing, and mobile phones run out of battery, that would be a concern…(I7)"*. Also, *"…One day, the electricity was turned off, and we told them about it, that I was on PD, and they told us to go to the hospital…(I1)"*.

4.4.3.3.6 Service

Service interruptions can impact on people with cancer, diabetes, respiratory conditions and renal diseases due to patients running out of medications and a reduction in treatment, care and services services. This can also create fear for people with NCDs, for example, *"...You really need to continue those chemo cycles, for it to be effective, and so the big concern there is that any disruption of this nature negatively effects on your treatment; it negatively effects on your ultimate outcome…(I8)"*. Also, *"...people with renal disease who would be on dialysis. I think public health infrastructure, if that were interrupted due to a disaster that would have a very serious impact on people with those conditions…(I7)"*.

4.4.3.3.7 Supplies

An interruption to the provision of, and access to, supplies can impact on people with diabetes due to insulin, testing strips and medication becoming exhausted and access to healthy food limited. For example, *"...I did live in the part that has next to no facilities, and I certainly think, as a diabetic, it would be very easy to run out of supplies and -- but that would be a very serious issue for diabetics…(I7)"*. Also, *"...if I were running low on food that would certainly be an issue. I mean, the risk of hypos and things like that, because you probably tend to be out and about and a bit more active during a disaster situation…(I7)"*.

4.4.3.3.8 Transport

Damage to transport can impact all people with NCDs due to a reduction in the number of clinicians able to access clinics, interrupted supply chains and preventing patients from getting home after treatment. For example, *"...I would be cut off completely. I live on one of the beaches, so getting things in or out would be an issue…(I6)"*. Another concern is that *"...if you can't get*

dialysis here and there is a cyclone, also it's likely that the airport will be closed as well…(I9)". Also, *"…Well, the only people I feel sorry for is the people out west…they come in for some of these treatments and they can't get home…(I2)"*.

4.4.3.3.9 Workforce

An interruption to the workforce can impact all people with NCDs due to reduced access. For example, *"…a diabetic educator just knows about diabetes….so if…you kept going low or you weren't sure what was going on…you would need to have someone to talk to…and give you some advice…(I6)"*.

4.4.3.3.10 Other

Becoming unwell during the preparation for a cyclone was identified as a concern for people with cancer. For example, *"…after Yasi, it basically made me ramp up my own individual personal preparations at home considerably more than what we had done previously, but, physically this time for Nathan, I was not able to do half of what I did. I actually made myself ill trying to prepare for it… (I8)"*.

4.4.3.4 Proposed mitigation strategies

There were 21 mitigation strategies proposed for reducing the risk of disaster exacerbated NCDs. The strategies have been categorised by PHI in Table 4-14 and are discussed in the following.

Table 4-14 Mitigation strategies proposed by people with NCDs

Infrastructure	Strategy	Participant example
Communication	Information for people with NCDs about service plans, including contact details	*"...it's knowing; it's having the information present, so knowing that there are plans; knowing…these are the phone numbers…and who you would contact... (I8)"*
	Multiple channels to contact healthcare providers and suppliers	*"...knowing ways that you can communicate with people who you need to, whether that was healthcare providers or suppliers…(I7)"*
	People with NCDs on a priority communication service	*"...I'm on a priority service, because I have an issue. I don't know whether that's something that still exists in disaster arrangement…(I6)"*
	Tailored health advice for people with NCDs	*"...tailoring some of those advices to make sure that people are remembering that they have got a condition and they need to make sure they're covered…(I6)"*
Equipment	Nil	N/A
Governance	Centralised register of people at risk	*"...there should be a register for people like me. This register, I presume, would be for people who would be incapacitated and have no family…(I10)"*
	Contingency plans available and shared with people at risk	*"...knowing that there are contingency plans, and what they are…(I8)"*
	State-wide continuity of service plans	*"... provisions for continuity of service…that's state-wide…(I8)"*
	Rapid deployment of health workforce	*"...Well, there should be medical practitioners lined up to help these people…in the event that there is an emergency, a heart attack, a seizure or something…(I10)"*
Physical structure	Disaster resilient health facilities	*"...a place here that was on higher ground and… and it had its own power…(I9)"*

	Shelter catering for people with NCDs	*"…a shelter…that the food or what was provided was catered for a type one diabetic…(I6)"*
Power	Generators for home based patients	*"…For me…definitely a good generator…(I5)"*
Prevention	Ability to self-manage	*"…Yeah, well, actually, it's up to yourself…(I4)"*
	Cyclone treatment packs for people with NCDs	*"…cyclone packs, just in case we can't get into dialysis…(I9)"*
	Health services located away from storm surge risk	*"…it would be ideal if there was a dialysis unit… inland further or higher ground or whatever…(I9)"*
Sanitation	Nil	*N/A*
Service	Health services provided in shelters	*"…Where the shelters are. They should be set up in a temporary surgery…(I10)"*
Supplies	Stockpile prescriptions, medication and nutritious food	*"…Access to medications, you're able to access those at home…(I4)"*
Surveillance	Database of people at risk	*"…having a database of people who are type one diabetics…(I6)"*
	Register of people with NCDs at shelters	*"…shelter…one of the first things I would want to do…is notify someone that I am a…diabetic...(I6)"*
Transport	Maintaining access to GPs, specialists and the hospital	*"…access to the GP and specialist…(I11)"*
Water	Nil	N/A
Workforce	Deployment of generators to home based patients	*"SES…provide generators…(I5)"*
	Plans to maintain access to health professionals (e.g. talk to diabetic educator)	*"A diabetic educator just knows about diabetes, so if you were in that situation…you would have someone that you can talk to and…give you some advice…(I6)"*

The mitigation strategies were recommended by eight of the 11 participants. Of this group all except one had been impacted by a disaster. In contrast, two of the three people who did not suggest a mitigation strategy had not been through a disaster.

Mitigation strategies were identified for communication, governance, physical structure, power, prevention, services, supplies, surveillance, transport and workforce. For communication, governance and prevention this included: people with NCDs being on a priority communication service, tailored health advice to people with existing conditions, centralised register of people at risk, early evacuation of people at risk and health services located away from storm surge risk. Physical structure, power, service and workforce strategies included: shelters catering for people with NCDs, generators for home based patients, health services provided in shelters, and plans to maintain access to health professionals. For supplies, surveillance and transport this included: stockpiling prescriptions, medications and nutritious food, database of people at risk, and transport plans to maintain access to general practitioners, specialists and the hospital.

4.4.4 *Discussion*

A breakdown of PHI and ongoing protections was identified as a key factor in reducing access to treatment, care and services, increasing the risk of acute exacerbation of existing conditions, worsening long-term prognosis and even death.[6,111] Ensuring PHI is protected before, during and after a disaster was identified as being vital for mitigating this risk. Mitigation strategies include: tailoring advice to the most vulnerable, maintaining a register of people at risk, providing patients with disaster packs, locating health services in disaster resilient locations, early evacuation and providing health services at shelters and evacuation centres.

The mitigation strategies proposed complement recommendations from other research and publications by providing a patient perspective. For example, the surveillance strategies have been recognised by the The Sphere Project, which recommends undertaking risk assessments based on knowledge of pre-emergency patterns and prevalence of NCDs.[16] The WHO recommends protecting health facilities and an inclusion of drugs and supplies in emergency health kits.[64] Also, ADEA recommends clear communication to patients about how to access health care and support their conditions post disaster.[115] A point of difference is that these publications are focused predominately on describing the need for maintaining treatment, care

and services, whereas this paper describes the how from a patient perspective. A common theme is the need to rapidly transition from a response and recovery focus to prevention and preparedness activities for people with NCDs.

A key step for shifting towards a prevention and preparedness focus would be a register of people at risk. This would help ensure disaster activities are tailored to people with NCDs *"…there should be a register for people like me. This register…would be for people who would be incapacitated and have no family…(I10)"*. This is particularly important because after a disaster has occurred and the response and rescue are underway it is nearly always "too little and too late" to ensure the most vulnerable, such as people with NCDs, can rapidly access the required treatment, care and services.[122,123]

Access to an accurate register would also help disaster planners cater for the needs of people with NCDs at evacuation centres and shelters. Participants were concerned that under current arrangements their treatment, care and services needs were unlikely to be met if evacuated. Often people evacuated leave home without medications and on arrival at an evacuation centre or shelter require new medication and access to treatment, care and services, which is not available.[10,124] Having access to this information would allow disaster planners to estimate the medications, treatment, care and services required at evacuation centres and shelters as part of standard disaster prevention and preparedness activities.

Development and implementation of an appropriate register would have challenges. These include: ethical concerns for sharing patient information, accuracy and maintenance, and the voluntary nature of registers. For example, registers in Australia are reliant on voluntary registration and this results in an underestimate of the people at risk.[104] In the State of Victoria, Australia, there is a population of almost six million with less than 1,350 registered as vulnerable.[105,106] This challenge could be overcome by developing and implementing an integrated system that allows local healthcare providers to provide and update information on vulnerable patients, with their consent, to disaster planners and decision makers at the local government level.[2] In locations with an integrated electronic medical record this could be as simple as adding a vulnerability tick box, which once ticked, automatically updated the local government vulnerability register.

The mitigation strategies are interconnected. If one strategy is not supported another is at risk of failing. To overcome this challenge, a collaborative governance approach is required to implement the mitigation strategies due to the wide range of disciplines, organisations and sectors involved.[14] This would be an amalgamation of people with NCDs and the government, non-government and private sectors.[107] This approach would complement the comprehensive, all hazards, all agencies approach to disaster management in Queensland, Australia.[109]

Incorporation of the proposed mitigation strategies into existing disaster-related performance and monitoring activities would help facilitate sustainable change. This would need to be complemented by: research on morbidity and mortality patterns during and following a disaster; and integrating NCDs into practical and academic training of disaster workers and emergency-response coordinators.[19] This approach would ensure PHI disaster mitigation and allow the ongoing care of people with NCDs to be integrated into system-wide policies, plans, programs and budgets.[2,13]

The next step for solving this problem is to verify the effectiveness of the mitigation strategies. For example, does effectiveness vary by NCD, disaster type and location? The Promoting Action on Research Implementation in Health Services (PARIHS) framework provides a good methodology for this to occur.[125] The framework has been successfully applied in the health sector and is effective in translating evidence into practice.[126] All the elements of PARIHS are in-place and following this type of methodology would provide the platform required for system-wide change. This would include interdisciplinary surveys, workshops, dialogue, research and training to ensure the strategies are tailored to local needs and maximise treatment, care and services for people with NCDs.

Finally, to reduce the risk of disaster exacerbated NCDs there will need to be an immediate shift in the health sector disaster prevention and preparedness activities beyond communicable diseases and immediate trauma to include NCDs.[2] This would include recognising the integral role PHI has in reducing disaster exacerbated NCDs. There must also be a focus by health and disaster systems on the diseases at greatest risk post disaster. These are people with cancer, cardiovascular diseases, diabetes, respiratory conditions and renal diseases; however, other NCDs such as mental health conditions and drug addiction must also be considered.[6] Achieving this will ultimately help implement the Sendai Framework and most importantly help maintain treatment management and care for people with NCDs before, during and after a disaster.

4.4.5 *Limitations*

The authors have been part of prevention, preparedness, response and recovery activities to cyclones that have impacted some of the areas subject to the research. To address this limitation, all authors worked together to develop the research design and crosscheck data.

A potential limitation was the research was limited to a high-income country setting. Caution should be taken to applying the findings to low and middle income countries, particularly as the PHI and NCD priorities may differ. However, the results will be useful in enhancing future disaster risk reduction activities.

The authors recognise pilot studies have a number of limitations. These include the fact that the "N" number is low and recognise that the possibility of making inaccurate predictions or assumptions and that different results could be generated from a larger study.[117,119] However, it should be noted the point of saturation was reached after interview 11. Also, this approach was selected to validate proposed strategies for solving this problem for the first time from a patient perspective. The authors consider this a vital step prior to developing a conceptual framework and mitigation strategies that provide a systematic guide for sustainably reducing the impact of disasters on people with NCDs.[118,119]

4.4.6 *Conclusion*

Natural disasters can breakdown PHI and ongoing protections, which reduces the access to treatment, care and services for people with NCDs. This increases the risk of acute exacerbation of existing conditions, worsening long-term prognosis and even death. Mitigation strategies include: tailoring advice to the most vulnerable, maintaining a register of people at risk, providing patients with disaster packs, locating health services in disaster resilient locations, early evacuation and providing health services at shelters and evacuation centres. A common theme was the need to rapidly transition from a response and recovery focus to prevention and preparedness. To achieve this there is a need to rank, prioritise and verify the proposed mitigation strategies. This will require a collaborative governance approach that complements the all hazards and all agencies approach to disaster management. The result would be an expansion beyond the traditional health sector focus in disaster management on communicable disease and immediate trauma to include NCDs. Achieving this will ultimately help implement

the Sendai Framework and most importantly help maintain treatment management and care for people with NCDs before, during and after a disaster.

4.5 Synthesis

The findings from the six focus groups and 42 interviews presented in this Chapter provide further evidence of the relationship between a disruption to PHI due to a disaster and an increased risk of NCD exacerbation or even death. Mitigation strategies were described for all phases of the disaster cycle. Specific measures include: increasing the use of telemedicine, preplanning with medical suppliers, effective town planning, health professionals visiting evacuation centres, evacuation centres having power for medical equipment, hubs for treatment, care and services after a disaster, evacuation of high risk people prior to disaster, mapping people at risk by NCD, and a mechanism for sharing information between agencies. A common theme was that having accurate and easily accessible data on people with NCDs would allow disaster service providers to adequately prepare for and respond to a disaster. The PHI priorities and mitigation strategies have been further analysed in Chapter 5.

Although the PHI themes described in Chapter 3 where verified, additional descriptors were identified for each except power (Table 4-15). The descriptors identified in the three papers were further synthesised/grouped in-line with the literature review. After this process the highest number of additional descriptors were for communication (n=5) followed by equipment (n=4), governance (n=4), services (n=4), surveillance (n=4), prevention (n=3), workforce (n=3), physical structure (n=2), supplies (n=2), other (n=2), sanitation (n=1), transport (n=1) and water (n=1). The expansion of PHI descriptors provides another step towards describing PHI priorities for disaster management systems. In addition, the emergence of the PHI theme "Other" reflects the need for further validation and prioritisation.

Table 4-15 – Additional public health infrastructure descriptors identified

Theme	Literature	Additional descriptors
Communication	Broadband; communication; cameras; electronic records; information sharing; information systems; information technologies; internet; media relations; mobile communication; referral system; satellite communication; signs; social media; technology; telecommunication; telephone; traffic lights. (n=18)	Advertising; community meeting; education/training; radio; television. (n=5)
Equipment	Beds; equipment; hand washing facilities; hospital beds; medical devices; refrigeration; sharps; water closets; water pumps. (n=9)	Charges; cooking facilities; earthmoving equipment; trucks. (n=4)
Governance	Agreements; business continuity; command and control; coordination; disaster system; emergency management committee; financial; funding; government; hospital system; interagency coordination; law enforcement; leadership; governance; legal administration. (n=14)	Legislation; non-government agencies; planning; policies and procedures. (n=4)
Physical structure	Buildings; community infrastructure; food storage; health facilities; healthcare; homes; hospital; hospital infrastructure; housing; medical facilities; medical infrastructure; physical infrastructure; primary care offices; shelter; storage facilities; structures. (n=16)	Accommodation; churches. (n=2)
Power	Electricity; energy; energy supply; generators; power; power plants; power supply; power lines. (n=8)	Nil.
Prevention	Prevention; promotion; public health prevention; research. (n=4)	Disease control; heat protection; vaccination programme. (n=3)
Sanitation	Drainage; hygiene; infection control; latrines; medical waste; plumbing; sanitation; sewage systems; solid-waste collection; waste disposal; waste management; wastewater; water disinfection; water treatment. (n=14)	Street cleaning. (n=1)

Services	Acute medical care; ambulance; business; clinics; communicable disease control; diagnosis; disinfection; education; emergency departments; emergency medical services; environmental health; epidemiology; filtration; food safety; health promotion; healthcare program; healthcare providers; laboratory services; medical care; medical practices; medical services; mental health; military; nursing homes; nursing services; public health surveillance; outpatient clinics; pharmacies; social service; supporting systems; surveillance; utilities; vaccine programs; welfare. (n=34)	Childcare centre; medication; morgues; nursing home. (n=4)
Supplies	Food; food supplies; food sources; fuel; gas; medical products; medications; medicine; mineral oil; natural gas; pharmaceutical supplies; prescription drugs; supplies; supply networks; vaccinations; water sources. (n=16)	Clothing; condoms. (n=2)
Surveillance	Assessments; health data; health information; monitor; mortality information; public health assessments. (n=6)	Contact tracing; data collection; flood mapping; personal information. (n=4)
Transport	Airport; bridges; footpath access; mobilization; road network; roads; subways; transport; transportation. (n=9)	Transport routes. (n=1)
Water	Dams; drinking water; water; water supply (n=4)	Water system. (n=1)
Workforce	Care coordinator; carers; emergency response trauma teams; epidemiologists; health professionals; jobs; nurses; personnel; pharmacist; public health officials; public health personnel; social professionals; staff; trained staff; workforce. (n=15)	Administration; contractors; volunteer groups. (n=3)
Other	N/A	Animals; pet care. (n=2)

This Chapter also found disaster service providers, including environmental health professionals, have a vital role in mitigating the impact of disasters on treatment, care and services for people with NCDs. They are often employed in communities where disasters occur and responsible for helping maintain PHI before, during and after a disaster. For this reason, they are best placed to lead implementation of the mitigation strategies. By focusing on the disaster cycle as a template, and on mitigation and prevention phases in particular, these actions and activities performed by disaster service responders will lead to overall improved preparedness, response and recovery.

To sustainably implement the mitigation strategies, they will need to become integrated into effective performance and monitoring of the disaster response and health sector during non-disaster periods. For this to occur, the strategies should be integrated into business and strategic plans. Achieving this will help implement the Sendai Framework and, most importantly, help protect the health of people with NCDs before, during and after a disaster. To provide the platform for this to occur a modified Delphi process has been conducted in Chapter 5 to rank and prioritise PHI priorities and mitigation strategies.

4.6 Conclusion

This Chapter found a relationship between the impact of a disaster on PHI and increased health risks for people with NCDs. Mitigation strategies were described for all phases of the disaster cycle impacting PHI. Specific strategies include: increasing the use of telemedicine, preplanning with medical suppliers, effective town planning, health professionals visiting evacuation centres, evacuation centres having power for medical equipment, hubs for treatment, care and services after a disaster, evacuation of high risk people prior to disaster, mapping people at risk by NCD, and a mechanism for sharing information between agencies. The expansion of PHI descriptors provides another step towards describing priorities for disaster management. The interdisciplinary nature of environmental health and disaster service providers demonstrated combined with their role in communities where disasters occur highlight they are well-placed to lead implementation of the mitigation strategies. This will require integration into effective performance and monitoring of the disaster response and health sector during non-disaster periods. To provide the platform for this to occur, PHI priorities and mitigation strategies have been ranked and prioritised in the next Chapter.

Chapter 4 References

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Chapter 5 Translating results

5.1 Overview

The results from the previous Chapters were used to inform a modified Delphi process that ranked and prioritised mitigation strategies for reducing the impact of disasters on people with NCDs. The chapter represents a peer-reviewed publication that incorporated questionnaire, workshop and survey results to recommend mitigation strategies.[1] This paper is provided in the following.

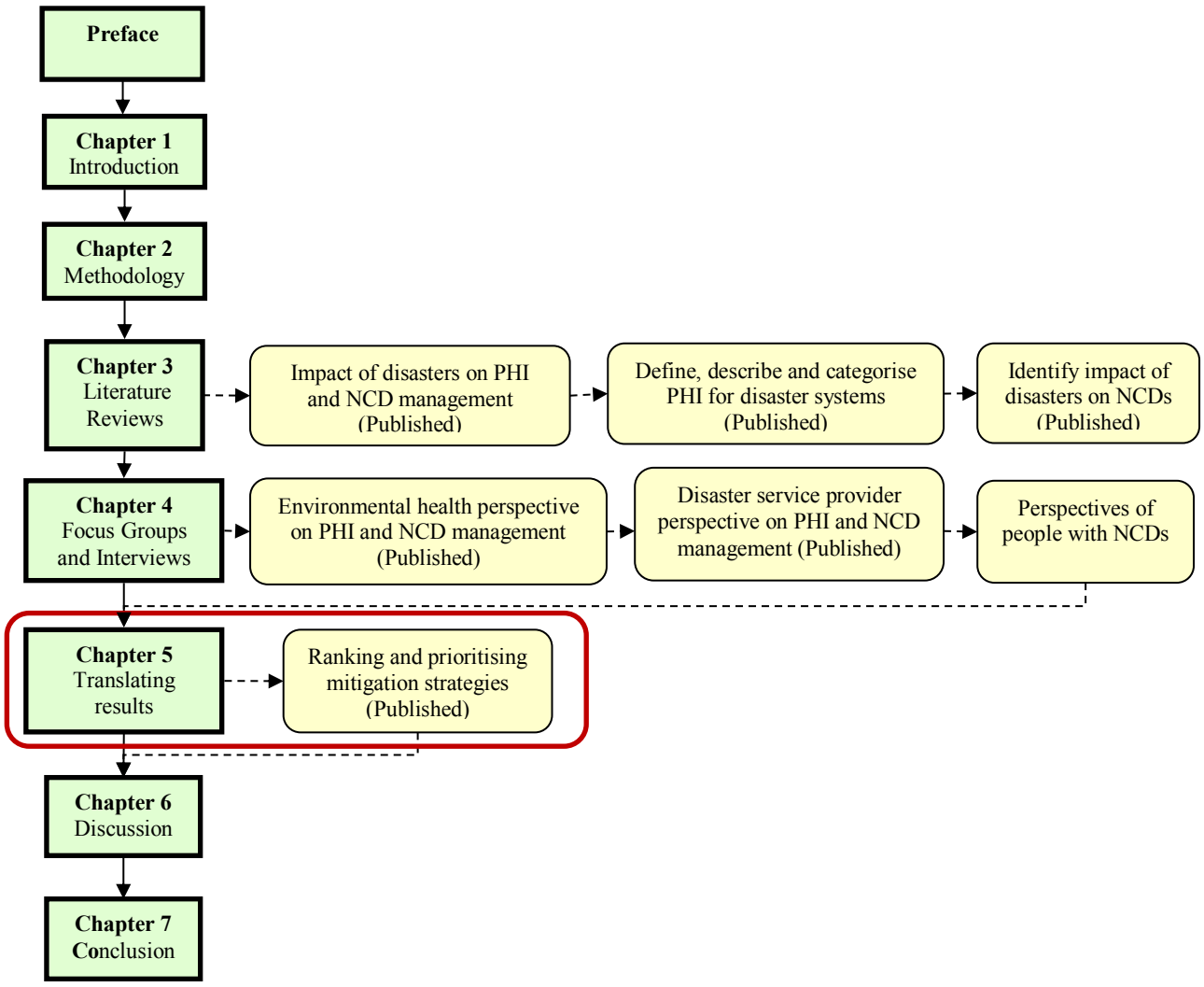

Figure 5-1 Chapter 5 position within thesis

5.2 Ranking and prioritising mitigation strategies

Published – Ryan BJ, Franklin RC, Burkle FM, Smith EC, Aitken P, Watt K and Leggat P (2018). Ranking and prioritizing strategies for reducing mortality and morbidity from noncommunicable diseases post disaster: an Australian perspective. International Journal of Disaster Risk Reduction. Vol 27:223-238. Impact factor 1.603 (Thomson Reuters 2017); Indexing EBSCOhost, Elsevier BV, Gale, National Library of Medicine, Ovid, ProQuest and Thomson Reuters; Google Scholar citations nil – Appendix F.

While natural disasters such as cyclones, hurricanes, floods, storms and tsunamis can cause significant "direct" mortality and morbidity, they also result in widespread damage to public health infrastructure (PHI) and the social protection systems required for vulnerable populations.[2] This contributes to what is referred to as "indirect" mortality and morbidity, primarily due to an acute exacerbation of noncommunicable diseases (NCD).[2-4] The threat of this occurring is anticipated to continue, if not increase, due to a combination of a growing NCD burden, climate change, deforestation and rapid urbanisation in flood plains and storm-prone coastal zones.[5-8]

NCDs including heart disease, stroke, cancer, diabetes and chronic lung disease are collectively responsible for almost 70% of all deaths worldwide.[9] Almost three quarters of all NCD deaths, and 82% of people who die prematurely (before reaching 70 years of age), occur in low- and middle-income countries.[9] Population ageing along with changes in lifestyle, increasing obesity and overweight, decreasing physical activity, environmental change and reduction in communicable disease in populations across the world has contributed to a "disease transition" to NCDs.[10-13] These conditions are also long-lasting and place a great burden on patients, health services and fiscal systems.[14,15]

When PHI and social protections such as equipment, food, shelter, treatment and safe water are not recovered or rehabilitated in a timely manner, a major and sustained "public health emergency" may occur.[2] For example, during Hurricane Katrina, 33% of people exhibited symptoms of chronic disease exacerbation when arriving at shelters and one year later there was a 33% reduction in cancer treatment services.[3,16,17] Other examples include: 19% increase in cancer related deaths in the 12 months after Hurricane Iniki in 1992 and during the weeks after four Hurricane's in Florida in 2004;[18,19] diabetes accounting for 5% of excess deaths after

the four Hurricane's in Florida; [17, 20] and in the 30 days after Hurricane Sandy, incidence of myocardial infarction increased by 22% and mortality by 31%.[20] A considerable proportion of healthcare attendances following natural disasters are also now due to NCDs. For example, in the five days after Severe Tropical Cyclone Yasi in 2011 there was a 40% increase in daily emergency department presentations at The Townsville Hospital, Australia, which was due to disrupted access to services for acute and chronic health care.[21]

There was also increased indirect mortality in the three months after the 2011 Great East Japan Earthquake, primarily due to NCDs.[22] For people over 60 years of age the mortality rate increased by 33% for those with cerebrovascular diseases, 37% with heart diseases (excluding hypertension), 54% with Chronic Obstructive Pulmonary Disease (COPD), 41% if on dialysis and 48% for endocrine, nutritional and metabolic diseases.[22] The mortality rate began to decrease in the second month for this cohort except for the 60-69 age group, where there was a 143% increase in mortality.

The United Nations Office for Disaster Risk Reduction (UNISDR) and World Health Organization (WHO) has identified the need to address this challenge. The *Sendai Framework for Disaster Risk Reduction 2015-2030* (Sendai Framework) item 30(k) requests that people with chronic diseases (also known as NCDs) are included in the design of policies and plans to manage their risks before, during and after disasters.[7] Reinforcing the WHO *Global Action Plan for the Prevention and Control of Noncommunicable Diseases – 2013-2020*.[23]

As part of building an evidence base to implement mitigation strategies for reducing disaster exacerbated NCDs, this study was part of the final phase for a broader project conducted by the authors in Queensland, Australia. This included literature reviews[3,24,25] and focus groups and interviews with people who have NCDs and disaster responders, coordinators and government officials (disaster service providers).[26,27] The state of Queensland has been the focus due to the high NCD burden and recent disasters.[15,28] For example, Severe Tropical Cyclone Larry (2006), flash flooding in the Lockyer Valley (2011); and Severe Tropical Cyclone Yasi (2011).[29] This research has found people with NCDs at greatest risk of their condition exacerbating or even death post disaster are those: with underlying cardiovascular and respiratory diseases; undergoing cancer treatment; with unstable diabetes; and with renal diseases, especially if receiving dialysis.[3]

To help reduce this risk, this study has ranked and prioritised mitigation strategies based on the perspectives of people with NCDs and disaster responders, coordinators and government officials (disaster service providers). The objectives included: ranking and prioritising mitigation strategies identified by people with NCDs and disaster service providers; comparing and contrasting PHI priorities for disaster management based on the perspectives of people with NCDs, disaster service providers and the literature; ranking mitigation strategies by PHI priority; and recommending priority mitigation strategies.

5.3 Material and Methods

The data was collected through a sequential modified Delphi process.[30] This included three phases: questionnaire (n=14) to recommend mitigation strategies for the survey phase; workshop (n=18) to explore questionnaire results; survey (n=552) to rank and prioritise the mitigation strategies. This approach was selected because it provided the opportunity to explore the research more deeply in different ways and develop mitigation strategies (proposed solution) ready for translation into practice.[31] Also, this reflected how the study was the final phase of a broader project that used the Promoting Action on Research Implementation in Health Services (PARIHS) framework to focus on developing mitigation strategies for reducing the risk of disaster exacerbated NCDs.[32] This included literature reviews[3,24,25] and focus groups and interviews with people who have NCDs and disaster service providers.[26,27]

An overview of the project methodology is provided in Figure 5-2 and a description of the terms used for the research, participants, recruitment strategy, data collection, analysis techniques and ethical considerations is provided in the following.

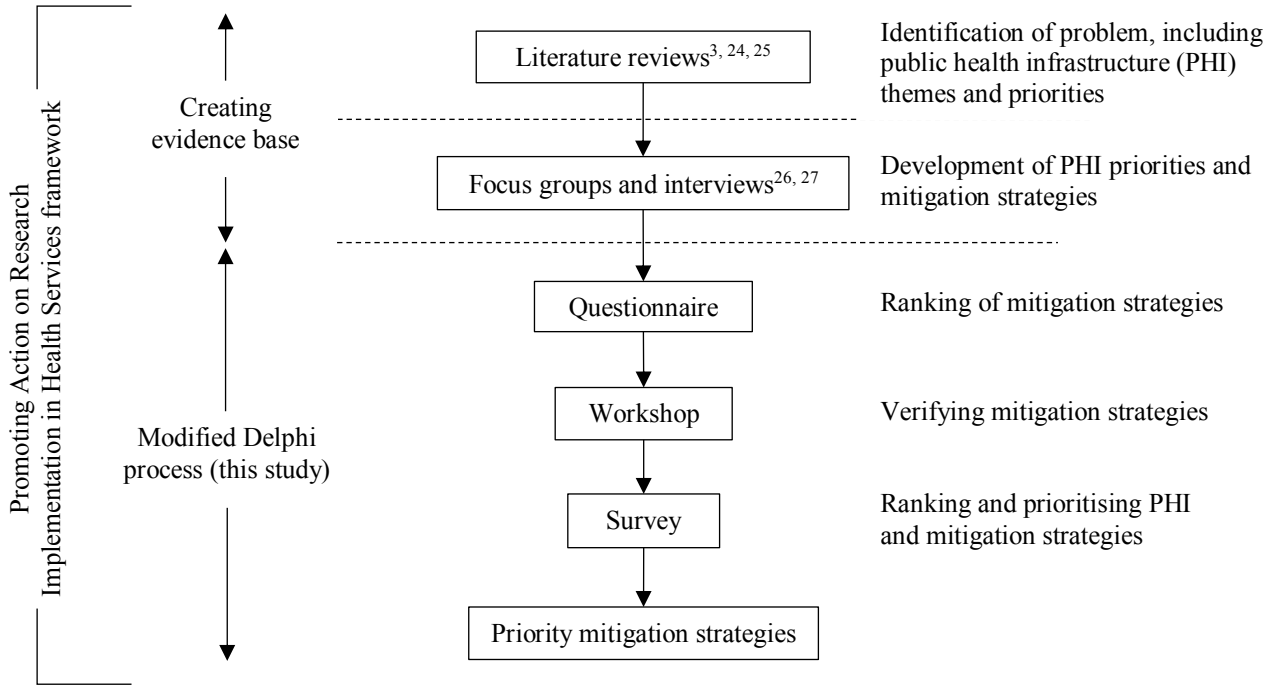

Figure 5-2 Research methodology

5.3.1 *Terms used for the research*

5.3.1.1 Public health infrastructure (PHI)

The PHI categories used in the research were: communication; equipment; governance; physical structure; power; prevention; finance; sanitation; services; supplies; surveillance; transport; water; and workforce.[25] The categories were modified from Ryan et al (2016, p.10) who defined PHI as "the workforce, equipment, supplies, and protection services required to maintain the health and wellbeing of individuals and the community".[25]

5.3.1.2 Noncommunicable disease (NCD)

The conditions considered most at risk of exacerbation after a disaster and account for the majority of the disease burden, healthcare costs and deaths across the world guided the analysis of this research. These included: cardiovascular diseases; cancers; chronic respiratory diseases; diabetes; mental health conditions; and renal diseases.[3,23,33]

5.3.2 *Participants*

The participants were people with NCDs and disaster service providers. A description of each is provided in the following.

5.3.2.1 People with NCDs

People with the most common NCDs in Queensland, Australia, and those at greatest risk post disaster were invited to participate. These include: cancer; cardiovascular disease; chronic respiratory disease; diabetes; mental health conditions; and renal diseases.[3,34] These conditions are not only at risk of exacerbation after a disaster but are long-lasting and place great burden on patients, health services and fiscal systems.[14,15]

5.3.2.2 Disaster service providers

Three types of disaster service providers were invited to participate: responders; coordinators; and government officials. This group was invited because their perceptions, experiences and knowledge are vital in influencing strategies for reducing disaster exacerbated NCDs. The use of these groups also ensured the study was consistent with, and able to build on, the earlier research conducted by the co-authors.[3,24-27] A description of each group is provided below:

- *Responders*: This group included doctors, nurses, paramedics, police officers and representatives from non-government organisations, such as the Australian Red Cross. The group is involved in the disaster preparedness, prevention, response and recovery arrangements.[35]

- *Coordinators*: This group included local disaster coordinators, disaster management officers and members of Local and District Disaster Management Group's. The group provides a conduit between the local, district and state levels of government and also has specialist knowledge of the principles and practices of disaster management.[35]

- *Government officials*: This group included representatives from the Department of Health (Queensland), Queensland Police Service, Queensland Fire and Emergency Services and Queensland Ambulance Service with a state-wide disaster management role. The group is predominantly based in Brisbane, the state capital

of Queensland, Australia. Overall this group leads, designs and manages state-wide preparation, prevention, response and recovery phases of disaster management.[35]

5.3.3 *Queensland, Australia, and the health system*

In Queensland, Australia, health services are delivered by 16 Hospital and Health Services (HHS) with a centralised Department of Health providing overall management including monitoring performance (Figure 5-3).[36] The term "Queensland Health" is commonly used and refers to both the Department of Health and HHSs.[37] Approximately 1 in 8 people in Queensland was aged 65 years or older in 2014, with the proportion forecast to increase to 1 in 5 by 2036, which will be a considerable driver of future health needs.

Figure 5-3 Map of Queensland Hospital and Health Services[38]

The majority of Queensland (90% of the land mass) is classified as remote or very remote with 97% of the 4.9 million people (20% of Australia's population) are clustered in coastal and hinterland areas.[39,40] Queensland's land mass is 1.7 million square kilometres (22.5% of Australia) and is five times the size of Japan, seven times the size of Great Britain, and two and a half times the size of Texas, USA.[41,42]

5.3.4 *Recruitment strategy*

A purposive sampling strategy was used to recruit participants.[43] For the questionnaire and workshop phase, Queensland Health was contacted to seek access to an expert group of disaster service providers. This "disaster health expert" group was selected because as a whole it

represents Queensland Health on Local, District and State Disaster Management Group's and would be responsible for leading implementation of the mitigation strategies across Queensland, Australia.[44] Recruitment for the survey phase included 25 letters and e-mails to different government organisations (n=7), non-government organisations (n=8) and NCD support agencies (n=10). The purpose was to seek their support to complete and distribute the survey across Queensland to people with NCDs and disaster service providers (Table 5-1). The recruitment strategy focused on maximising participation.

Table 5-1 Organisations invited to circulate the survey

Organisations	Type
Asthma Australia	NGO – Support organisation for providers and people with NCDs
Australian College of Rural and Remote Medicine	NGO – Support organisation for providers
Australian Diabetes Educators Association	NGO – Support organisation for providers and people with NCDs
Australian Medical Association	NGO – Support organisation for providers
Australian Red Cross	NGO – Support organisation for providers and people with NCDs
Cancer Council Queensland	NGO – Support organisation for providers and people with NCDs
Department of Communities, Child Safety and Disability Services	Government – Provider
Diabetes Queensland	NGO – Support organisation for providers and people with NCDs
Environmental Health Australia	NGO – Support organisation for providers
Health Consumer Queensland	NGO – Support organisation for providers and people with NCDs
Inspector-General Emergency Management	Government – Provider
Kidney Health Australia	NGO – Support organisation for providers and people with NCDs

Kidney Support Network	NGO – Support organisation for providers and people with NCDs
Local Government Association of Queensland	NGO – Support organisation for providers
Lung Foundation Australia	NGO – Support organisation for providers and people with NCDs
Northern Queensland Primary Health Network	NGO – Support organisation for providers
Pharmacy Guild	NGO – Support organisation for providers
Public Health Association of Australia	NGO – Support organisation for providers
Queensland Ambulance Service	Government – Provider
Queensland Fire and Emergency Service	Government – Provider
Queensland Health	Government – Provider and NCD support organisation
Queensland Police Service	Government – Provider
Royal Australian College of General Practitioners	NGO – Support organisation for providers
The Heart Foundation	NGO – Support organisation for providers and people with NCDs
Townsville Hospital and Health Service	Government Provider

5.3.5 *Data collection and analysis techniques*

The data was collected and analysed through three sequential phases: a questionnaire and workshop with disaster health experts; and state-wide survey of people who had a NCD and disaster service providers. The data collection and analysis techniques varied for each phase and is described in the following.

5.3.5.1 Questionnaire

An expert group was engaged to complete a questionnaire focused on determining if each of the 76 mitigation strategies, adapted from earlier research (focus groups and interviews)[26,27], should be kept, removed or clarified. The mitigation strategies were categorised by theme,

which was based on the PHI identified in the literature[25]. The questionnaire was a series of closed and open questions where participants could provide comments and recommendations.

The questionnaire was completed by 14 participants on the first day of the Queensland Health Disaster Symposium (symposium) on 5 September 2016. A descriptive analysis was used to analyse the data. The results were explored at the symposium workshop on 6 September 2016. Where participants indicated clarification was required, group discussion occurred at the workshop to determine if the strategy should be reworded and kept, removed or even if another should be added.

5.3.5.2 Workshop

The purpose of the workshop was to explore the results from the questionnaire and help inform mitigation strategies that would be included in the survey phase. The workshop was conducted with 18 disaster health experts on the second day of the symposium (6 September 2016). The number of participants was higher than the recommended 10-15 for a Delphi workshop but this could not be avoided due to time-constraints and participant convenience.[45] To ensure effectiveness of the workshop two assistants facilitated. The workshop was tape-recorded and the second author took notes on the feedback provided.

The workshop focused on the mitigation strategies recommended for removal and clarification in the questionnaire process. The recommended cut-off is 10%, which is the prevailing figure where a minority can reverse the opinions of a majority.[46] However, due to time-constraints and the number of participants the cut-off figures for discussion were modified. The mitigation strategies discussed were those where 15% or more of participants recommended removal and where 40% or more suggested clarification.

The decision on removal, clarification and addition of a mitigation strategy was determined when consensus was achieved, which is consistent with the Delphi process.[45] The second author recorded this consensus position on a hard-copy questionnaire. The workshop was designed to allow open creative discussion, which also provided the opportunity for participants to recommend additional mitigation strategies. The finalised mitigation strategies were included in the survey.

5.3.5.3 Survey

The survey was available electronically via SurveyGizmo (operated Widgix Software, LLC©) and was completed by participants from 21 September and 22 December 2016. There were 552 responses with 370 surveys analysed after application of the exclusion criteria, which included incomplete surveys, responses from people outside Queensland and participants who indicated they did not have a NCD or a role in disaster management.

The aim was to rank and prioritise mitigation strategies for reducing indirect mortality and morbidity post natural disaster from the perspectives of people with NCDs and disaster service providers. Members of the expert group involved in the questionnaire and workshop were invited to complete the survey, as they were a disaster service provider.

The survey design was based on the findings from literature reviews[3,24,25], focus groups and interviews[26,27], questionnaire and workshop. Prior to launching the survey there was a process of testing and refinement. This included reviews by all authors and testing with a small group of people (n=5) who had a NCD and/or worked in disaster management. The survey four paths depending on whether a participant had: a noncommunicable disease; was a disaster service provider; had both a NCD and was a disaster service provider; and did not have a NCD and was not a disaster service provider.

Data collected was entered into IBM© SPSS© Statistics Version 23. Descriptive statistics was used to group differences such as people with NCDs and disaster service providers, people with different NCDs and those who have not experienced a disaster. The analysis occurred through the phases of: descriptive analysis to describe the distribution and range of responses to each variable; recoding data into categories where appropriate, for example, ages into age ranges, to enable a meaningful comparison of sub-groups; and prioritisation of mitigation strategies.[47]

5.3.6 *Prioritisation of public health infrastructure (PHI)*

The rankings of PHI by people with NCDs and disaster service providers who completed the survey were compared with Ryan et al (2016, the literature)[25]. The purpose was to inform PHI priorities for reducing indirect mortality and morbidity from NCDs post natural disaster. To achieve this a simple categorical method was applied.[48]

While completing the survey people with NCDs and disaster service providers ranked the importance of each PHI theme for maintaining treatment, care and services in the categories of "Not applicable", "Low", "Medium" and "High". The selection of "High" was used to determine the PHI priority with the highest number considered the most important. The priority ranking for each PHI within the respective category was then aggregated to provide a prioritisation score.[25] For example, if a PHI theme was ranked "one" by people with NCDs, "three" by disaster service providers and "four" in the literature, the aggregated total would be eight. The PHI theme with the lowest aggregated score was the most important.

5.3.7 *Prioritisation of mitigation strategies*

The mitigation strategies where grouped by PHI theme in the survey and prioritised by disaster service providers as either "Not applicable", "Clarification required", "Low", "Medium" and "High". The question about specific mitigation strategies was only completed if the respective PHI theme was rated as "High". Consistent with the consensus approach to this research mitigation strategies were only considered a priority where there was a general agreement of substantial majority, which was considered 75% or more.[49] The mitigation strategies that reached this threshold were ranked by priority within the respective PHI theme based on the percentage of "High". The rankings were then prioritised by the PHI theme priority order. A responsible area was then allocated based on the categories of people with NCDs, responders, coordinators and government officials, which were modified from Ryan et al[26]. Further information on this process is provided in Figure 5-4.

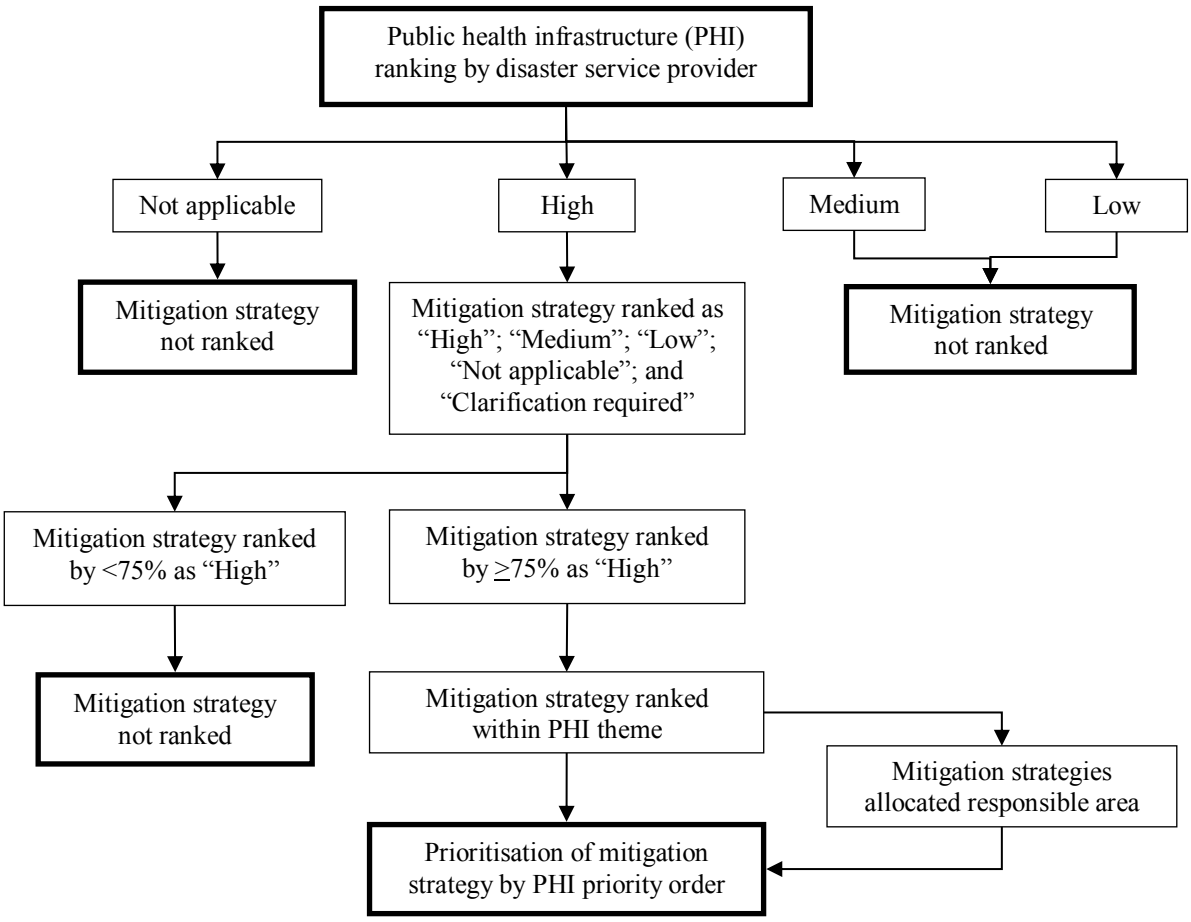

Figure 5-4 Process for prioritising mitigation strategies

5.3.8 *Ethical considerations*

Ethical approval was provided by James Cook University (H6646), Australia, and Townsville Hospital and Health Service Human Research Ethics Committee (HREC/16/QTHS/67), Australia. This was complemented by letters to organisations seeking permission to invite staff, members and people with NCDs to participate in the research.

5.3.8.1 Theory

The constructivism philosophy best described the theoretical approach to this research (Chapter 5). Constructivism recognises that a research problem (in this instance disaster risk and high-burden of NCDs) informs the initial methodological choices for data collected and that the researcher is part of the study.[50] The overall research direction was guided by data gathered from literature reviews, focus groups and interviews to inform the methodology for this project.[3,24-27]

The findings from the earlier phases of the broader project provided preliminary validation of a theory that mitigation strategies can be implemented to reduce the impact a disaster can have treatment, care and services for people with NCDs.[3,24-27] For this reason, the research project was guided by the PARIHS framework.[32] This approach was selected because the PARIHS framework has been successfully applied by health professionals to implement evidence into practice.[51] Also, the first two of three elements were already in-place. Firstly, members of this research team created the evidence-base through literature reviews, focus groups and interviews.[3,24-27] Secondly, the context was in-place, which was demonstrated by the high burden of NCDs, risk of disasters in the research area and the strong recommendation of the Sendai Framework.[7,28,44] The third element, facilitation was the focus of this phase because the solution required a complete system change.[52] The facilitation phase of PARIHS was a sequential modified Delphi process.[30]

5.4 Results

5.4.1 *Questionnaire*

The questionnaire was completed by seven female and male participants. The most common age grouping was 35-44 (n=6) followed by 45-54 (n=4), 25-34 (n=3) and 55-64 (n=1). All participants worked with Queensland Health and had a role in disaster management. The participants were from the geographical areas of Brisbane (n=5), Townsville Hospital and Health Service (HHS) (n=2), West Moreton HHS (n=2), Cairns and Hinterland HHS (n=1), Central Queensland HHS (n=1), Darling Downs HHS (n=1), North West HHS (n=1) and Wide Bay HHS (n=1). The Brisbane area included the Metro North and South HHSs geographical areas.

Of the 76 mitigation strategies proposed in the questionnaire, there were 22 strategies that 90% or more of participants indicated should be kept, 44 where 10% or more of participants indicated clarification was required and ten where 10% or more recommended removal (Table 5-2). Using the 10% cut-off there were eight strategies that were recommended for both clarification and removal.

Table 5-2 Mitigation strategies kept, removed or clarified

PHI category	Strategy	Questionnaire recommendation (n=14; *13)			Workshop outcome (n=18)
		Keep	Remove	Clarify	
Communication	Brochures about how to maintain your health and wellbeing located at evacuation centres and shelters	13 (93%)	1 (7%)	0	Not discussed.
	Central contact point for people with NCDs	7 (50%)	2 (14%)	5 (36%)	Removed.
	Consistent and clear messages about where people can go for assistance after a disaster	12 (86%)	0	2 (14%)	Not discussed.
	Information about preparedness for people with NCDs in rates notices and on Council websites	8 (57%)	1 (7%)	5 (36%)	Replace with: “Information about preparedness for people with NCDs on Council websites”.
	Regular disaster warnings and reminders via SMS; Facebook; Twitter; radio; television	12 (86%)	0	2 (14%)	Not discussed.
	Targeted preparedness messaging to people with NCDs*	12 (92%)	0	1 (8%)	Not discussed.

	Local disaster groups coordinate preparedness communication for people with NCDs	5 (36%)	4 (29%)	5 (36%)	Replace with: "State Government lead development of preparedness messages for people with NCDs". Also, recommended addition of the following strategies: "Local health service facilitates preparedness messages for people with NCDs"; "Information about preparedness activities available from GPs, support groups and specialists"; and "Information about where to receive treatment, care and services post disaster available at evacuation centres and shelters"
	Portable mobile phone towers	10 (71%)	2 (14%)	2 (14%)	Not discussed.
	Back-up power provided to the telephone exchange	12 (86%)	1 (7%)	1 (7%)	Not discussed.
Equipment	People with NCDs having back-up equipment (for example, spare oxygen cylinders)*	12 (92%)	1 (8%)	0	Not discussed.
	Waterproof treatment kits	11 (79%)	0	3 (21%)	Not discussed.
	Health services maintain surplus equipment during disaster season	8 (57%)	1 (7%)	5 (36%)	Not discussed.

Finance	Mobile ATMs positioned in disaster affected areas	12 (86%)	1 (7%)	1 (7%)	Not discussed.
	Banks capable of opening immediately post disaster	11 (79%)	1 (7%)	2 (14%)	Not discussed.
	Rapid deployment of officials to provide financial aid	13 (93%)	0	1 (7%)	Not discussed.
Physical structure	Store back-up medication in a secure location	13 (93%)	0	1 (7%)	Not discussed.
	Hubs for treatment, care and services set up around schools, evacuation centres and shelters	11 (79%)	0	3 (21%)	Not discussed.
	Providing people with NCDs a purpose built facility to maintain treatment during a disaster	2 (14%)	5 (36%)	7 (50%)	Kept.
	Health services designed to be disaster resilient	12 (86%)	0	2 (14%)	Not discussed.
	Safe storage for fuel	13 (93%)	0	1 (7%)	Not discussed.
Governance	Annual community-wide day of readiness for disasters	14 (100%)	0	0	Not discussed.
	Educating the community on how to assist a person with medical issues after a disaster	11 (79%)	1 (7%)	2 (14%)	Not discussed.

Encouraging personal responsibility for disaster preparedness	14 (100%)	0	0	Not discussed.
Health representation at disaster management groups	14 (100%)	0	0	Not discussed.
Interagency planning for maintaining treatment, care and services	13 (93%)	0	1 (7%)	Not discussed.
Locally led planning, response and recovery	14 (100%)	0	0	Not discussed.
Plans for people who cannot self-medicate at home	10 (71%)	0	4 (29%)	Remove.
Provide a centralised system for coordinating transport to treatment, care and services	6 (43%)	0	8 (57%)	Replace with: “Designated primary healthcare hubs post disaster” and move to PHI infrastructure category of physical structure.
Resilient communication between health services and disaster management groups	13 (93%)	0	1 (7%)	Not discussed.
Private practices have plans to reduce reliance on the hospital system after a disaster	14 (100%)	0	0	Not discussed.

Power	Back-up power for people reliant on medical equipment (for example, home oxygen patients)*	10 (77%)	0	3 (23%)	Not discussed.
	General Practitioner clinics with back-up power	12 (86%)	0	2 (14%)	Not discussed.
	Provide charging stations for medical equipment at evacuation centres	12 (86%)	1 (7%)	1 (7%)	Not discussed.
Prevention	Patients having a list of emergency contacts	14 (100%)	0	0	Not discussed.
	Education led by the agency providing care to people with NCDs	10 (71%)	0	4 (29%)	Not discussed.
	Evacuate people with NCDs who are most vulnerable	8 (57%)	1 (7%)	5 (36%)	Not discussed.
	Clinicians work with patients to develop disaster plans	9 (64%)	2 (14%)	3 (21%)	Removed.
	People with NCDs understanding their vulnerabilities	13 (93%)	0	1 (7%)	Not discussed.
	Systems in-place to allow people with NCDs to return home as soon as possible after a disaster	11 (79%)	1 (7%)	2 (14%)	Not discussed

	Include people with NCDs in disaster exercises	7 (50%)	2 (14%)	5 (36%)	Replace with: “Consider the needs of people with NCDs during disaster exercises”.
	Clinicians encourage patients to discuss disaster planning with their family	14 (100%)	0	0	Not discussed
	Town planning to reduce the vulnerability of health services to a disaster	12 (86%)	0	2 (14%)	Not discussed
	Audits of disaster preparedness activities such as maintenance of generators, equipment and telecommunication systems*	12 (92%)	0	1 (8%)	Not discussed
Sanitation	Prioritise access to safe water for people with NCDs	7 (50%)	1 (7%)	6 (43%)	Kept.
	Good hygiene practices implemented at evacuation centres and shelters	14 (100%)	0	0	Not discussed
	Good hygiene practices in the home environment	12 (86%)	1 (7%)	1 (7%)	Not discussed

	Evacuate people with NCDs who are at an increased risk of infection from poor sanitation standards post disaster	8 (57%)	2 (14%)	4 (29%)	Replace with: “As a last resort, evacuate people with NCDs who cannot access essential care”; and “Proactively evacuate people with NCDs who may not be able to access essential care post disaster”
	Food businesses maintaining good hygiene standards	13 (93%)	1 (7%)	0	Not discussed.
Services	Streamlining processes for patients to access medication after a disaster	11 (79%)	0	3 (21%)	Not discussed.
	Access to telemedicine after a disaster	12 (86%)	0	2 (14%)	Not discussed.
	General Practitioners having plans in-place to resume services immediately after a disaster	13 (93%)	0	1 (7%)	Not discussed.
	Health professionals visit evacuation centres and other mass gathering locations	9 (64%)	0	5 (36%)	Not discussed.
	Provide treatment, care and services at multiple sites	11 (79%)	0	3 (21%)	Not discussed.
	Provide emergency child care for clinician families post disaster	11 (79%)	0	3 (21%)	Not discussed.

Supplies	Plans to rapidly deploy medication to impacted communities	12 (86%)	0	2 (14%)	Not discussed.
	Health services maintain surplus medication supplies during disaster season	9 (64%)	0	5 (36%)	Replace with: “Health services have a surplus of consumables during disaster season”; and “Health services identify options for rapidly sourcing additional consumables to treat people with NCDs”.
	Nutritious food options provided at evacuation centres and shelters	9 (64%)	1 (7%)	4 (29%)	Replace with: “People who are reliant on a specific diet bring their own food to evacuation centres and shelters”.
	Patients bring medication to evacuation centres	14 (100%)	0	0	Not discussed.
Surveillance	Central registration point for people with NCDs	5 (36%)	2 (14%)	7 (50%)	Removed.
	Community-wide mapping of people with NCDs	7 (50%)	2 (14%)	5 (36%)	Not discussed.
	General Practitioners forwarding details of patients most at risk to local disaster groups prior to a disaster	5 (36%)	2 (14%)	7 (50%)	Kept.

	Readily accessible data for disaster groups on the treatment trends and needs of a community*	10 (77%)	1 (8%)	2 (15%)	Not discussed.
Transport	Evacuation of high-risk people prior to disaster	8 (57%)	0	6 (43%)	Kept.
	Use boats as an alternate option for transporting patients*	8 (62%)	1 (8%)	4 (31%)	Not discussed.
	Use planes to transport patients*	12 (92%)	0	1 (8%)	Not discussed.
	Use helicopters to transport patients*	12 (92%)	0	1 (8%)	Not discussed.
	Buses used to transport patients*	12 (92%)	0	1 (8%)	Not discussed
Water	Evacuation of people with NCDs who are reliant on safe water for treatment	7 (50%)	1 (7%)	6 (43%)	Kept.
	Water purification plant with back-up power	7 (50%)	1 (7%)	6 (43%)	Replace with: “Water treatment plants with back-up power”
	Alternate water supply for people with NCDs (e.g. bottled water or rainwater tanks)	9 (64%)	1 (7%)	4 (29%)	Not discussed.
Workforce	Health professionals contacting patients after a disaster	9 (64%)	1 (7%)	4 (29%)	Not discussed.

Health professionals provide telemedicine care for patients impacted by disaster	12 (86%)	0	2 (14%)	Not discussed.
Health professionals to visit evacuation centres and other mass gatherings after a disaster	9 (64%)	0	5 (36%)	Not discussed.
Rapid deployment of health professionals to areas impacted by a disaster	9 (64%)	1 (7%)	4 (29%)	Not discussed.
Staff trained in disaster management systems	14 (100%)	0	0	Not discussed.
Access to tradespeople to maintain equipment and physical structures post disaster	10 (71%)	1 (7%)	3 (21%)	Not discussed.

All participants agreed to keep ten strategies. These were: “Annual community-wide day of readiness for disasters”; “Encouraging personal responsibility for disaster preparedness”; “Health representation at disaster management groups”; “Locally led planning, response and recovery”; “Private practices have plans to reduce reliance on the hospital system after a disaster”; “Patients having a list of emergency contacts”; “Clinicians encourage patients to discuss disaster planning with their family”; “Good hygiene practices implemented at evacuation centres and shelters”; “Patients bring medication to evacuation centres”; and “Staff trained in disaster management systems”. The strategies where all participants suggested they should be kept were in the PHI categories of governance (n=5), prevention (n=2), sanitation (n=1), supplies (n=1) and workforce (n=1).

All PHI categories were included in the 47 mitigation strategies where 10% or more of participants indicated clarification was required. The highest proportion was in the surveillance and water categories (100% or 4/4 and 3/3, respectively). This was followed by services and workforce (83% or 5/6 for each); supplies (75% or 3/4); equipment and power (66% or 2/3 for each); communication (66% or 6/9); prevention and physical structure (60% or 6/10 and 3/5, respectively); sanitation and transport (40% or 2/5 for each); finance (33% or 1/3); and governance (30% or 3/10).

There were eight mitigation strategies requiring clarification in the PHI categories of surveillance (n=2); water (n=2); physical structure (n=1); governance (n=1); sanitation (n=1); and transport (n=1). Of this group, there was one also recommended for removal. This provided a total of seven mitigation strategies for discussion about clarification at the workshop. These included: “Provide a centralised system for coordinating transport to treatment, care and services”; “Prioritise access to safe water for people with NCDs”; “Central registration point for people with NCDs”; “General practitioners forwarding details of patients most at risk to local disaster groups prior to a disaster”; “Evacuation of high-risk people prior to disaster”; “Evacuation of people with NCDs who are reliant on safe water for treatment”; and “Water purification plant with back-up power”.

The ten mitigation strategies recommended for removal by 10% or more of participants were in the PHI categories of surveillance (75% or 3/4); communication (33% or 3/9); prevention (20% or 2/10; physical structure (20% or 1/5); and sanitation (20% or 1/5). When adjusted to the 15% cut-off used for the workshop, there were two strategies recommended for removal in

the PHI categories of communications and physical structure. The strategies were: "Local disaster groups coordinate preparedness communication for people with NCDs"; and "Providing people with NCDs a purpose built facility to maintain treatment during a disaster" (also recommended for clarification).

5.4.2 *Workshop results*

The workshop included nine female and male participants. The most common age grouping was 45-54 (n=7) followed by 35-44 (n=5), 25-34 (n=4) and 55-64 (n=2). All participants worked with Queensland Health and had a role in disaster management. The participants were from the geographical areas of Brisbane (n=8), Townsville HHS (n=2), West Moreton HHS (n=2), Cairns and Hinterland HHS (n=1), Central Queensland HHS (n=1), Darling Downs HHS (n=1), Gold Coast HHS (n=1), Northwest HHS (n=1) and Wide Bay HHS (n=1). The Brisbane area included the Metro North and South HHSs geographical areas.

The workshop discussed 17 mitigation strategies. All mitigation strategies were presented to participants with a focus on the seven mitigation strategies recommended for clarification in the questionnaire phase along with the two recommended for removal. As the workshop progressed the participants discussed an additional eight mitigation strategies. These included: "Central contact point for people with NCDs"; "Information about preparedness for people with NCDs in rates notices and on Council websites"; "Plans for people who cannot self-medicate at home"; "Evacuate people with NCDs who are most vulnerable"; "Clinicians work with patients to develop disaster plans"; "Include people with NCDs in disaster exercises"; "Health services maintain surplus medication supplies during disaster season"; and "Nutritious food options provided at evacuation centres and shelters".

As a result of the workshops there were eight mitigation strategies replaced, five kept and four removed. In some instances, replacement included the addition of mitigations strategies. Overall, there was no change in the number of mitigation strategies for the survey.

5.4.3 *Survey results*

There were 552 survey responses. After reviewing the responses 182 were excluded, which provided 370 for analysis. Of the respondents excluded, 120 included participants did not have

a NCD or a role in disaster management, 52 did not sufficiently complete the survey (for example, stopped after answering the demographic questions), seven were from outside Queensland and three were from outside Australia.

Of the survey participants, 62% were female and 38% male. The highest age grouping was 45 to 54 (33%) followed by 55 to 64 (21%), 35 to 44 (20%), 25 to 34 (13%), 65 or older (8%) and 18 to 24 (4%) with the remainder preferring not to answer (1%). People with a NCD made up 42% (n=156) of responses with 42% (n=66) of this group also working or volunteering in disaster management (18% of all participants). There was just over 1% (n=5) of participants who did not wish to advise if they had a NCD.

The majority of participants were from Brisbane (24%). This was followed by the Cairns and Hinterland HHS (21%), Townsville HHS (21%), Mackay HHS (8%), Sunshine Coast HHS (6%), Darling Downs HHS (5%), Wide Bay HHS (4%), Central Queensland HHS (4%), Gold Coast HHS (3%), West Moreton HHS (2%), Torres and Cape HHS (2%) and North West HHS (less than 1%). Other locations reported included regional Queensland (1%), rural Queensland (1%) and rural South-East Queensland (less than 1%). The Brisbane geographical area included the Metro North and South HHSs geographical areas. There was one participant who selected an "other" location, but did not complete the non-mandatory sub-question about their location.

The majority of participants had experienced a disaster (85%). The most frequently reported disaster type experienced was a cyclone (n=234) followed by flood (n=224), bushfire (n=99), earthquake (n=39), tornado (n=15) and tsunami (n=4). Participants reported other disaster experiences such as: drought (n=3), storm (n=2), disease outbreak (n=2) and heatwave.

5.4.3.1 People with NCDs

Of the 156 participants with NCDs, 78% had experienced a disaster. The most frequently reported disaster type experienced was a cyclone (n=104) followed by flood (n=72), bushfire (n=34), earthquake (n=13) and tornado (n=2). The other type of disasters experienced was a storm and heatwave.

The Cairns and Hinterland HHS was the geographical area recording the most NCD participants (28%). This was followed by Townsville HHS (25%), Brisbane (23%), Mackay HHS (9%), Central Queensland HHS (3%), Gold Coast HHS (3%), Sunshine Coast HHS (3%),

Darling Downs HHS (2%), Torres and Cape HHS (1%), West Moreton HHS (1%), North West HHS (1%) and Wide Bay HHS (1%). The Brisbane area included the Metro North and South HHSs geographical areas. There was one participant who selected an "other" location but did not complete the non-mandatory sub-question about their location.

The most frequently reported NCDs were respiratory conditions (n=38) and cardiovascular diseases (n=36). This was followed by mental health (n=29), diabetes (n=22), renal disease (n=16) and cancer (n=14). The other conditions reported were arthritis (n=6), autoimmune diseases (n=3), coeliac disease (n=3), hashimoto's disease (n=3), multiple sclerosis (n=3), sleep apnoea (n=3), endocrine disorders (n=2), inflammatory bowel syndrome (n=2), menier's disease (n=2), thyroid conditions (n=2), spinocerebellar ataxia (n=2), fibromyalgia, liver and biliary dyskinesia, peripheral neuropathy and prostatic hyperplasia. There were also participants who indicated they had a pancreatic (n=2) and kidney (n=1) transplant. Of this group, 20% reported that they had two NCDs, 3% had three different types of NCDs and less than 1% had four different NCDs.

5.4.3.2 Disaster service providers

Of the 280 people who indicated they had a role in disaster management, 89% had experienced a disaster. The most frequently reported disaster type experienced was a flood (n=192) followed by cyclone (n=175), bushfire (n=81), earthquake (n=30), tornado (n=15) and tsunami (n=4). Other disaster types experienced included disaster drought (n=3), disease outbreak (n=2) and storm (n=2).

The most frequently reported role was a paramedic (n=87) followed by emergency services (n=50), disaster coordinator/planner (n=44), manager (n=37), other (n=29), nurse (n=26), administration officer (n=19), environmental health officer (n=18), volunteer (n=17), doctor (n=5), police officer (n=6), director (n=4), fire fighter (n=4) and military (n=3).The other roles included allied health (n=2), ambulance dispatcher, carer, Chair of Local Disaster Management Group, communications, counsellor (n=2), data management, government employee, human and social recovery, human resources, intelligence and planning, pharmacist, manager of general practice, public health office (n=2), recovery centre manager, rescue helicopter, resilience and preparedness, social work (n=2), transport, urban search and rescue and waste management advisor. The volunteer roles/organisations specified included: Australian Red Cross (n=2); emergency reserve; firefighter; Lions Australia (n=2); Local Disaster

Management Group; surf lifesaving (n=2); prehospital medical team; and State Emergency Service (n=2).

Brisbane was the geographical area that had the most disaster service provider participants (27%). This was followed by Townsville HHS (20%), Cairns and Hinterland HHS (15%), Sunshine Coast HHS (8%), Mackay HHS (7%), Darling Downs (6%), Wide Bay HHS (5%), Central Queensland HHS (5%), Gold Coast HHS (3%), Torres and Cape HHS (2%), West Moreton HHS (1%) and North West HHS (less than 1%). Other locations reported included regional Queensland (1%), rural Queensland (1%) and rural South-East Queensland (less than 1%). The Brisbane area included Metro North and South HHSs geographical areas. There was one participant who selected an "other" location but did not complete the non-mandatory sub-question about their location.

5.4.4 *Public health infrastructure (PHI) priorities – comparison with literature*

The highest priority PHI identified by both people with NCDs and disaster service providers was water (70% of NCD group ranked "High" and 89% of disaster service providers), meanwhile, the literature ranked the workforce as the most important (Table 5-3). Workforce was ranked number one in the literature but ranked seven by people with NCDs and disaster service providers (41% and 71% ranked "High", respectively). Physical structure was ranked number eight by both people with NCDs and disaster service providers (33% and 59% ranked "High", respectively) and in comparison it was ranked six by the literature. The greatest contrast was within the PHI theme of services, which was ranked number five by people with NCDs (51% "High"), disaster service providers ranked it ten (56% "High") and the literature number 11. Surveillance was ranked low by all three groups (18% of NCD group ranked "High" and 26% of disaster service providers) with only finance being ranked a lower priority by people with NCDs (17% ranked "High").

Table 5-3 Public health infrastructure priorities

Order	People with NCDs (% ranked high)	Disaster service providers (% ranked high)	Literature*	Overall Ranking (score**)
1	Water (70%)	Water (89%)	Workforce	Water (4)
2	Supplies (58%)	Communication (87%)	Water	Communication (10)
3	Communication (55%)	Power (83%)	Sanitation	Sanitation (12)
4	Sanitation (54%)	Supplies (82%)	Equipment	Workforce (15)
5	Services (51%)	Sanitation (80%)	Communication	Supplies (16)
6	Power (49%)	Equipment (71%)	Physical structure	Power (16)
7	Workforce (41%)	Workforce (71%)	Power	Equipment (19)
8	Physical structure (33%)	Physical structure (59%)	Governance	Physical structure (22)
9	Equipment (31%)	Transport (58%)	Prevention	Services (26)
10	Prevention (29%)	Services (56%)	Supplies	Governance (31)
11	Transport (29%)	Governance (44%)	Services	Prevention (31)
12	Governance (19%)	Prevention (37%)	Transport	Transport (32)
13	Surveillance (18%)	Finance (30%)	Surveillance	Surveillance (40)
14	Finance (17%)	Surveillance (26%)		Finance***

* Finance was not included in the literature.
** Ranking for each category was added to give overall score. Lower the score, higher the overall ranking.
*** No score because finance was not included in the literature.

After the ranking from the groups were combined, the highest-ranking PHI was water (score 4). The next four highest rankings in order were communication (score 10), sanitation (score 12), workforce (score 15), supplies (score 16) and power (score 16). The next grouping of rankings was equipment (score 19), physical structure (score 22) and services (score 26). This was followed by a grouping of governance (score 31), prevention (score 31) and transport (score 32). The lowest ranked PHI themes were surveillance (score 40) and finance (no score as not included in the literature).

5.4.5 *Ranking and prioritisation of mitigation strategies*

The mitigation strategies in Table 5-4 were ranked and prioritised by disaster service providers and organised by the PHI priorities. When combining the PHI priority and ranking of "High" in importance for maintaining treatment, care and services for people with NCDs, the highest priority mitigation strategy was considered "Water treatment plants with back-up power" (82% of disaster service providers ranked "High"). The mitigation strategy with the highest overall ranking was "Good hygiene practices implemented at evacuation centres" (92% of disaster service providers ranked "High"). The PHI theme with the most responses was water, which was reflected by the number of disaster service providers who ranked this as "High" (n=176) in importance for maintaining treatment, care and services for people with NCDs.

Table 5-4 Ranking and prioritising mitigation strategies by public health infrastructure

PHI them by priority order	Mitigation strategies	Clarify	N/A	Low	Med	High
Water (n=176 and 175)	Water treatment plants with back-up power	2%	1%	2%	13%	82%
	People with NCDs have access to at least three days' worth of safe water	3%	1%	3%	15%	78%
	Alternate water supply for people with NCDs (e.g. bottled water)*	2%	1%	4%	21%	72%
	Evacuation of people with NCDs who are reliant on safe water for treatment	5%	1%	10%	22%	63%
Communication (n=172)	Consistent and clear messages about where people can go for assistance after a disaster	0	2%	2%	12%	84%
	Back-up power provided to the telephone exchange	1%	1%	4%	15%	79%
	Information about where to receive treatment, care and services post disaster available at evacuation centres and shelters	1%	1%	3%	19%	77%
	Regular disaster warnings and reminders via SMS; Facebook; Twitter; radio; television	0	0	2%	23%	75%
	Portable mobile phone towers	4%	1%	4%	29%	64%
	Targeted preparedness messaging to people with NCDs	1%	1%	7%	29%	63%
	Local health service facilitates preparedness messages for people with NCDs	3%	1%	6%	37%	53%
	Information about preparedness activities available from GPs, support groups and specialists	0	0	7%	42%	51%

	State Government lead development of preparedness messages for people with NCDs	4%	1%	9%	36%	51%
	Information about preparedness for people with NCDs on Council websites	2%	2%	11%	39%	47%
	Brochures about how to maintain your health and wellbeing located at evacuation centres and shelters	1%	2%	19%	37%	41%
Sanitation (n=164)	Good hygiene practices implemented at evacuation centres and shelters	1%	1%	1%	7%	92%
	Food businesses maintaining good hygiene standards	1%	1%	1%	17%	81%
	Prioritise access to safe water for people with NCDs	4%	1%	3%	18%	74%
	Evacuate people with NCDs who are at an increased risk of infection from poor sanitation standards post disaster	3%	0	4%	26%	67%
	Community-wide messages about the need to maintain good hygiene practices in the home environment	2%	0	3%	29%	66%
Workforce (n=137)	Rapid deployment of health professionals to areas impacted by a disaster	2%	0	3%	10%	86%
	Staff trained in disaster management systems	0	0	4%	19%	77%
	Health professionals to visit evacuation centres and other mass gatherings after a disaster	1%	2%	4%	25%	69%
	Access to tradespeople to maintain equipment and physical structures post disaster	0	2%	2%	33%	64%
	Health professionals provide telemedicine care for patients impacted by disaster	4%	2%	9%	29%	56%

	Health professionals contacting patients after a disaster	2%	3%	12%	31%	51%
Supplies (n=164)	Plans to rapidly deploy medication to impacted communities	1%	1%	1%	13%	85%
	Patients bring medication to evacuation centres	2%	1%	2%	10%	84%
	Health services identify options for rapidly sourcing additional consumables to treat people with NCDs	2%	1%	1%	19%	78%
	Health services have a surplus of consumables during disaster season	4%	1%	4%	20%	72%
	Pharmacies identify options for rapidly sourcing additional consumables to treat people with NCDs	1%	1%	2%	24%	72%
	People who are reliant on a specific diet bring their own food to evacuation centres and shelters	4%	2%	10%	31%	53%
Power (n=147 and 146)	Back-up power for people reliant on medical equipment (for example, home oxygen patients)	4%	0	4%	8%	84%
	Provide charging stations for medical equipment at evacuation centres	1%	1%	9%	14%	75%
	General Practitioner clinics with back-up power*	2%	1%	9%	30%	58%
Equipment (n=145)	Health services have plans in-place to rapidly source the equipment required to treat people with NCDs	1%	1%	3%	11%	84%
	People with NCDs having back-up equipment (for example, spare oxygen cylinders and generator)	1%	1%	6%	17%	75%
	Storage of equipment in waterproof containers	4%	1%	5%	26%	65%
	Designated primary healthcare hubs post disaster	2%	1%	4%	13%	80%

Physical structure (n=106)	Health services designed to be disaster resilient	2%	0	2%	19%	77%
	Safe storage for fuel	2%	0	6%	21%	72%
	Store back-up medication in a secure location	2%	0	2%	26%	71%
	Providing people with noncommunicable diseases a purpose built facility to maintain treatment	3%	2%	17%	39%	40%
Services (n=97)	Streamlining processes for patients to access medication after a disaster	1%	1%	2%	13%	83%
	General Practitioners having plans in-place to resume services immediately after a disaster	0	2%	1%	19%	78%
	Health professionals visit evacuation centres and other mass gathering locations	1%	0	1%	24%	74%
	Provide treatment, care and services at multiple sites	4%	0	2%	21%	73%
	Provide emergency child care for clinician families post disaster	3%	0	6%	38%	53%
	Access to telemedicine after a disaster	5%	0	5%	42%	47%
Governance (n=85)	Encouraging personal responsibility for disaster preparedness	0	0	2%	18%	80%
	Locally led planning, response and recovery	0	0	2%	21%	77%
	Multiple communication methods between health services and disaster management groups	0	1%	2%	21%	75%
	Interagency planning for maintaining treatment, care and services	0	0	5%	20%	75%
	Health representation at disaster management groups	0	0	1%	26%	73%

	Private practices have plans to reduce reliance on the hospital system after a disaster	0	1%	5%	31%	64%
	Provide a centralised system for coordinating transport to treatment, care and services	1%	0	4%	33%	62%
	Educating the community on how to assist a person with medical issues after a disaster	0	0	12%	31%	58%
	Annual community-wide day of readiness for disasters	4%	1%	13%	34%	48%
Prevention (n=73)	Regular audits of disaster preparedness activities such as maintenance of generators, equipment and telecommunication systems	1%	0	0	14%	85%
	People with NCDs understanding their vulnerabilities	0	0	1%	18%	81%
	Patients having a list of emergency contacts	0	1%	1%	16%	81%
	Consider the needs of people with NCDs during disaster exercises	0	0	3%	22%	75%
	Town planning to reduce the vulnerability of health services to a disaster	1%	0	3%	21%	75%
	As a last resort, evacuate people with NCDs who cannot access essential care	6%	0	1%	26%	67%
	Proactively evacuate people with NCDs who may not be able to access essential care post disaster	1%	0	4%	29%	66%
	Clinicians encourage patients to discuss disaster planning with their family	3%	0	4%	27%	66%
	Systems in-place to allow people with NCDs to return home as soon as possible after a disaster	1%	1%	6%	29%	63%

	Education led by the agency providing care to people with NCDs	1%	1%	3%	38%	56%
Transport (n=96)	Evacuation of high-risk people prior to disaster	4%	0	1%	24%	71%
	Buses used to transport patients	4%	2%	12%	31%	51%
	Use planes to transport patients	6%	2%	9%	32%	50%
	Use helicopters to transport patients	6%	1%	13%	32%	48%
	Use boats as an alternate option for transporting patients	6%	1%	18%	35%	40%
Surveillance (n=48)	Readily accessible data for disaster groups on the treatment trends and needs of a community	2%	0	2%	23%	73%
	General Practitioners forwarding details of patients most at risk to local disaster groups prior to a disaster	4%	0	4%	38%	54%
	Community-wide mapping of people with NCDs	4%	2%	6%	33%	54%
Finance (n=55)	Rapid deployment of government officials to provide financial support	0	0	2%	20%	78%
	Mobile ATMs positioned in disaster affected areas	2%	0	13%	31%	55%
	Banks have capability to open immediately after a disaster	0	2%	9%	40%	49%

Consistent with the consensus approach to this research, mitigation strategies were only considered a priority where there was a general agreement of substantial majority, which was considered 75% or more.[49] The mitigation strategies meeting this figure were shaded "grey". Based on this approach the number of mitigation strategies was reduced from 79 to 31 mitigation strategies across 12 PHI themes. Prevention was the PHI theme with the most mitigation strategies that met the 75% threshold (n=5) followed by communication (n=4), governance (n=4), supplies (n=3), equipment (n=2), power (n=2), physical structure (n=2), sanitation (n=2), services (n=2), water (n=2), workforce (n=2) and finance (n=1).

There were 41 mitigation strategies ranked between 50% and 74% as "High" in importance for maintaining treatment, care and services for people with NCDs. Within this group, there were 11 mitigation strategies over 70%. This included the PHI themes of physical structure (n=2), services (n=2), supplies (n=2), governance (n=1), sanitation (n=1), surveillance (n=1), transport (n=1) and water (n=1). There were two mitigation strategies where 74% of disaster service providers ranked the importance as "High". These included: "Prioritise access to safe water for people with NCDs" (sanitation); and "Health professionals visit evacuation centres and other mass gathering locations" (workforce).

Seven mitigation strategies had less than 50% of disaster service providers ranking their importance as "High". These included: "Providing people with noncommunicable diseases a purpose built facility to maintain treatment" (physical structure – 40% ranked "High"); "Use boats as an alternate option for transporting patients" (transport – 40% ranked "High"); "Brochures about how to maintain your health and wellbeing located at evacuation centres and shelters" (communication – 41% ranked "High"); "Information about preparedness for people with NCDs on Council websites" (communication – 47% ranked "High"); "Use helicopters to transport patients" (transport – 48% ranked "High"); "Annual community-wide day of readiness for disasters" (governance – 48% ranked "High"); and "Banks have capability to open immediately after a disaster" (finance – 49% ranked "High").

5.4.5.1 Priority mitigation strategies

There were 31 mitigation strategies identified across 12 PHI themes as priorities for helping maintain the treatment, care and services of people with NCDs before, during and after disaster. The mitigation strategies were categorised by the PHI priority order and the ranking of "High" within each theme with a responsible area for implementation recommended in Table 5-5.

Table 5-5 Priority mitigation strategies by public health infrastructure – responsible area

PHI by priority order	Prioritised mitigation strategies	Recommended responsibility			
		Individual	Responder	Coordinator	Government Official
Water	Water treatment plants with back-up power				x
	People with NCDs have access to at least three days' worth of safe water	x			
Communication	Consistent and clear messages about where people can go for assistance after a disaster		x	x	x
	Back-up power provided to the telephone exchange				x
	Information about where to receive treatment, care and services post disaster available at evacuation centres and shelters		x		
	Regular disaster warnings and reminders via SMS; Facebook; Twitter; radio; television				x
Sanitation	Good hygiene practices implemented at evacuation centres and shelters		x		
	Food businesses maintaining good hygiene standards		x		x
Workforce	Rapid deployment of health professionals to areas impacted by a disaster		x	x	x

	Staff trained in disaster management systems		x		x
Supplies	Plans to rapidly deploy medication to impacted communities		x	x	x
	Patients bring medication to evacuation centres		x		x
	Health services identify options for rapidly sourcing additional consumables to treat people with NCDs			x	x
Power	Back-up power for people reliant on medical equipment (for example, home oxygen patients)			x	x
	Provide charging stations for medical equipment at evacuation centres				x
Equipment	Health services have plans in-place to rapidly source the equipment required to treat people with NCDs			x	x
	People with NCDs having back-up equipment (for example, spare oxygen cylinders and generator)	x			
Physical structure	Designated primary healthcare hubs post disaster		x		x
	Health services designed to be disaster resilient			x	x
Services	Streamlining processes for patients to access medication after a disaster				x
	General Practitioners having plans in-place to resume services immediately after a disaster		x		x

Governance	Encouraging personal responsibility for disaster preparedness		x	x	x
	Locally led planning, response and recovery		x		
	Multiple communication methods between health services and disaster management groups		x	x	x
	Interagency planning for maintaining treatment, care and services		x	x	x
Prevention	Regular audits of disaster preparedness activities such as maintenance of generators, equipment and telecommunication systems				x
	People with NCDs understanding their vulnerabilities	x	x	x	x
	Patients having a list of emergency contacts	x			
	Consider the needs of people with NCDs during disaster exercises		x	x	x
	Town planning to reduce the vulnerability of health services to a disaster				x
Finance	Rapid deployment of government officials to provide financial support				x

This research has identified the mitigation strategies within the PHI theme of water should be the highest priority for maintaining treatment, care and services for people with NCDs. Within this category, the highest ranked mitigation strategy was the need for "Water treatment plants with back-up power". The second highest priority PHI theme was communication with "Consistent and clear messages about where people can go for assistance after a disaster" considered the most important mitigation strategy. This was followed in order by the PHI themes of sanitation, workforce, supplies, power, equipment, physical structure, services, governance, prevention and finance.

The responsible area recommended to implement the highest number of mitigation strategies was government officials with 25 across all PHI themes. This was followed by responders with 16, coordinators 12 and people with NCDs four. There was one mitigation strategy in the PHI theme of prevention recommended to be implemented by all areas, which was "People with NCDs understanding their vulnerabilities". Seven mitigation strategies were identified as requiring support for implementation from responders, coordinators and government officials in the PHI themes of (in priority order): communication; workforce; supplies; governance; and prevention. Of the mitigation strategies recommended for government officials, six were recommended as being their sole responsibility, meanwhile, there were three each for people with NCDs, coordinators and responders.

5.5 Discussion

The mitigation strategies prioritised in Table 5-5 provide a major contribution towards helping reduce NCD indirect mortality and morbidity post natural disaster by providing the platform required for a strategic and targeted approach. For example, "Ensuring water is available for people with NCDs" should be the first priority. This would include "Ensuring water treatment plants have back-up power" and "People with NCDs have at least three days' worth of safe water". If the water issues are addressed then the remaining PHI priorities and associated mitigation strategies can become the focus. This would include in order: communication followed by sanitation, workforce, supplies, power, equipment, physical structure, services and governance, prevention and finance. However, it is vital to understand the mitigation strategies are interrelated and together provide a theoretical basis for addressing this problem.

The PHI priority order developed provides a strategic template to design and implement practical solutions across the disaster cycle. The process of contrasting the perspectives of people with NCDs, disaster service providers and the literature[25] has provided a form of validation and platform required to recommend PHI priorities. For example, PHI services were ranked five by people with NCDs but lower by disaster service providers and the literature highlighting that priorities for those impacted by a disaster can vary with those leading activities across the disaster cyclone. This perspective along with others have been incorporated into the results. This provides confidence PHI priorities and the associated mitigation strategies are strategic, targeted and can be more easily integrated into performance and monitoring across disciplines.[26]

An important finding was the priority given to "Designated primary healthcare hubs post disaster over health services being designed to be disaster resilient" and the "Use of a purpose built facility for people with NCDs". This further demonstrates the need to expand the traditional focus of disaster systems beyond the management of immediate trauma and communicable diseases to the most vulnerable populations such as those with NCDs.[26] While recognising and acknowledging the critical role of the formal emergency response agencies in the existing system of specialized health response, the strength of primary healthcare (for example, local general practitioners, pharmacists and nurses) has been recognised by this study.[53,54] Primary healthcare providers in communities at risk of disaster must be systematically integrated into the existing systems through designated hubs. This will provide clear responsibilities and lines of communication, avoid duplication of services and most importantly help reduce indirect morbidity and mortality post disaster by helping ensure continuity of care.[53,55]

The highest proportion of participants with NCDs were from Cairns and Hinterland HHS, meanwhile, for disaster service providers this was Brisbane. This geographical difference further highlights the need for future policies, priorities and activities across the disaster cycle to be inclusive of the perspectives of those affected by a disaster. Achieving this would reflect the emerging risks, diversity and intensity of recent disasters and show a sign of maturity across government in the prevention, preparedness, response and recovery phases.[56]

The research findings deliver on the strong recommendation of the Sendai Framework to include people with chronic diseases (also known as NCDs) in the design of policies and plans.

People with NCDs along with disaster service providers were involved in the development, ranking and prioritising of the mitigation strategies. Achieving implementation will be a challenge because there has been a history of unsatisfactory translation of disaster research findings into practical actions.[57] The co-authors are confident this can be overcome due to the application of the PARIHS framework for the broader research project, which has previously been used to effectively translate research into practice, and the use of a modified Delphi approach for this study.[51] An overview of the steps required for implementation is provided in the following.

5.5.1 *System-wide change*

A system-wide change will be required to implement the mitigation strategies. This includes increased support for clinicians, nurses, allied health professionals and those working in the non-acute sector.[53,58,59] In an attempt to stimulate this change the UNISDR Office for Northeast Asia and Global Education and Training Institute partnered with the Northern Queensland Primary Health Network, Australia, to deliver capacity building workshops for health sector provider groups.[54] This was a good start; however, further work is required to ensure the disaster and health systems can sustainably meet the treatment, care and services needs of people with NCDs before, during and after a disaster.[60,61]

Disaster plans in government, non-government and private sectors must recognise the relationship between how NCD morbidity and mortality post disaster is influenced by the level of PHI preparedness and the subsequent access provided to treatment, care and services. This shift is required because disasters are often measured and considered in terms of direct consequences; however, the majority of losses (as high as 70%–90%) are indirect deaths that would not have occurred without the breakdown of PHI.[62] Indirect mortality and morbidity is also rarely subject of disaster plans or political attention and for the most part remain undetected, unmeasured and under evaluated.[63] The feasibility for the expanded focus has been demonstrated by the people responsible for designing and implementing disaster policies and plans (disaster service providers) and those at risk (people with NCDs) being involved in the research.

5.5.2 *Collaborative governance approach*

Due to the range of sectors, organisations and disciplines involved in disaster management, implementation will require a collaborative governance approach.[64] For example, the highest priority identified by this research post disaster was access to water but the controls are not part of the health sector. Water supply in Queensland is predominately provided by local government with support from business and other agencies to treat, transmit or reticulate potable water. There is also a risk that this may not be seen as a priority by agencies outside health, which demonstrates the need for cross-sectoral planning at a whole of government level, which is the foundation of collaborative governance.[64]

The collaborative governance approach would commence with disaster system leaders articulating the need to participate in the interests of people with NCDs and risk of disasters (incentive to participate).[65,66] This would be followed by: face-to-face dialogue; trust building; developing a shared understanding; engaging in comprehensive and shared planning; pooling and jointly acquiring resources; and achieving intermediate outcomes (small wins) such as implementing the mitigation strategies.[65,66] Such an approach would be an amalgamation of organisations beyond the current disaster management system (government agency focus) to allow educational, community and private organisations such as universities, primary health care sector (general practitioners and pharmacies) and transport companies to help solve this problem.[26,67] Through this approach an open, inclusive and constructive dialogue would occur to create shared values for addressing this problem.[68]

5.5.3 *Evaluation of mitigation strategies*

Following implementation of the mitigation strategies, there would need to be an evaluation of their effectiveness. The evaluation process would be vital because most disaster related studies describe those cases in a coroner or medical examiner's office, or at a hospital or emergency room, with no effort to describe the denominator population from which the cases are drawn.[69] A process for achieving this could be describing patient presentations to the Emergency Department of a tertiary level hospital at sites with the mitigation strategies in-place with a focus on: patient demographics (age and gender), triage categories, and classification of diseases.[21] This could be complemented by cluster samples in rapid needs assessments after a cyclone, flood or storm related disaster, which could be generalized to a larger population.[69]

The aim would be to measure effectiveness of the mitigation strategies as well as gathering information about the distribution of indirect morbidity and mortality across different populations. The result would not only support implementation of the Sendai Framework but also provide a strategic and sustainable approach to reducing indirect mortality and morbidity from NCDs post natural disaster.

5.5.4 *Limitations*

The research was limited to Queensland, Australia, where the greatest disaster risks are cyclones, floods and storms. For this reason, caution is urged when applying the findings to other disaster types. However, the authors are confident the findings can be transferred to the same disaster types across the world where there are similar disease burdens/trends but caution is urged as all systems are unique.

The research was limited to a high-income country setting. This limits the transferability of the findings to low and middle-income countries because the PHI, disaster system and NCD priorities and challenges may differ.

The workshop with disaster health experts used 15% or more as the cut-off for exploring questionnaire results. The recommended cut-off is 10%, the prevailing figure where a minority can reverse the opinions of a majority.[46] The figure was modified due to time-constraints. To reduce the impact of this limitation, participants were provided with an opportunity openly discuss any mitigation strategies of interest. In addition, there was the opportunity to verify and validate all mitigation strategies during the survey phase.

A potential limitation was that people with NCDs were not requested to rank and prioritise mitigation strategies. The authors selected this approach to maximise the number of people with NCDs who could complete the survey by reducing the time required to participate. The impact is considered minimal by the authors as people with NCDs were involved in earlier research (interviews and focus groups) that focused on developing mitigation strategies. In addition, there were opportunities in the survey to add free text comments and predominately disaster service providers are responsible for leading implementation of the mitigation strategies identified.

Another limitation is that the lead author's professional and research experience in the public health aspects of disasters influenced the research direction. To mitigate this limited, all authors assisted with the study design.

5.6 Conclusion

Providing access to safe water should be the first priority for people with NCDs post natural disaster. The next priorities, in order, should be the strategies related to communication, sanitation, workforce, supplies, power, equipment, physical structure, services, governance, prevention and finance. However, it is vital to understand all mitigation strategies are interrelated and together provide a theoretical basis for addressing this problem. To implement the mitigation strategies, they must be integrated into monitoring and performance measures for the disaster and health sectors during non-disaster periods. This would require a collaborative governance approach due to the range of sectors, organisations and disciplines involved in disaster management. The result would not only support implementation of the Sendai Framework but also provide a sustainable approach towards reducing NCD mortality and morbidity post natural disaster.

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Chapter 6 Discussion

6.1 Introduction

The frequency of natural disasters and increasing noncommunicable diseases (NCD) burden across the world has created a need for disaster and health systems to expand focus beyond immediate trauma and communicable diseases. People with NCDs require access to public health infrastructure (PHI) such as water, services and supplies post disaster to maintain their health and wellbeing. However, disasters can and do impact the PHI, which can result in an increased risk of acute exacerbation of NCDs, worsening long-term prognosis and even death.[1-3] The people with NCDs at greatest risk are those with underlying cardiovascular and respiratory diseases, undergoing cancer treatment, unstable diabetes and renal diseases.[1] This risk is anticipated to continue, if not increase, due to an increasing NCD burden and climate change, deforestation and rapid urbanisation in flood plains and storm-prone coastal zones.[4-7]

To help reduce the risk, this PhD investigated the impact of cyclone, flood and storm related disasters on PHI and the management of NCDs, and developed strategies for mitigating the risks identified. Data was sequentially collected and analysed over three sequential phases: literature reviews (phase one)[1,3,8]; focus groups and interviews (phase two)[9,10], and a modified Delphi process (phase three)[11]. This sequential and triangulation research methodology allowed the findings to be chronologically verified and validated. The process allowed: relationships between PHI and NCD management to be explored in detail; ongoing refinement and testing of emerging ideas; development and verification of new strategies; and enhanced generalisability of the findings. This informed development of the conceptual framework, which offers disaster and health planners a systematic process for understanding how to ensure disaster preparation, response, and recovery encompasses the entire PHI spectrum and reflects needs of people with NCDs.

Strategies for mitigating the impact of cyclone, flood and storm related disasters on treatment, care and services for people with NCDs were identified by this research. This included 31 mitigation strategies across 12 PHI themes. Water was identified as the most important PHI theme.[11] If this fails, it has the greatest impact on the health and wellbeing of people with NCDs. Once water supply is addressed, the remaining forms of PHI and the associated mitigation strategies can be progressively resolved.[3,11] The next most important areas identified

were communication followed by sanitation, workforce, supplies, power, equipment, physical structure, services, governance, prevention, transport, surveillance and finance.[3,11] These findings informed development of a conceptual framework, which is discussed in the following along with options for implementing mitigation strategies, future considerations and research limitations.

6.2 Conceptual framework for addressing NCDs in disasters

The conceptual framework for addressing NCDs in disasters (framework) provides a theoretical mechanism for understanding how PHI preparedness can reduce the impact of disasters on people with NCDs (Figure 6-1). It does this by reflecting the relationship between how the impact of a disaster on NCD morbidity and mortality is influenced by the level of PHI preparedness and the subsequent access provided to treatment, care and services. This has been developed through a sequential mixed methods exploratory approach (qualitative followed by quantitative). This included: literature reviews (phase one)[1,3,8]; focus groups and interviews (phase two)[9,10]; and a modified Delphi process (phase three).[11] This approach effectively explored relationships, refined and tested emerging ideas, developed new strategies and allowed generalisability of the mitigation strategies (findings).[12] In addition, the six peer-reviewed publications provides further theoretical validation of the framework.

The research found access to water was the most important of the PHI themes identified.[11] If this fails, it has the greatest impact on the health and wellbeing of people with NCDs. For example, reducing access to hydration and treatment such as dialysis, restricting the ability for compounding pharmacies to operate, and increasing the risk of infection for the immunocompromised.[10] The research found once water supply is addressed, the remaining forms of PHI and the associated mitigation strategies can be progressively resolved.[3,11] Communication (for example, messages to people with NCDs) should then be resolved followed by (examples in brackets): sanitation (hygiene practices); workforce (access to physicians, medical officers, nurses or telemedicine); supplies (medication); power (electricity through generators); equipment (oxygen cylinders); physical structure (shelter); services (access to treatment and care); governance (coordination of transport); prevention (education for those at risk); and finance (mobile automatic teller machines).

It is important to note PHI and the reciprocal mitigation strategies are interrelated and often if one component fails access to treatment, care and services for people with NCDs may be compromised. For example, it may not be possible to address water and sanitation issues without power, which may be reliant on supplies such as electrical lines that need be repaired post disaster by a workforce requiring equipment and transport into the affected area. Response and recovery activities for each PHI theme may also occur in parallel as different professions and agencies have varying responsibilities (for example, power is often the responsibility of electrical companies and supplies logistics experts). For these reasons, disaster and health planners must work with and across professions and agencies to ensure preparations and responses can meet the needs of people with NCDs. However, for this to be effective, the relationship between how NCD morbidity and mortality post disaster is influenced by the level of PHI preparedness and the subsequent access provided to treatment, care and services must be understood and reflected in disaster plans

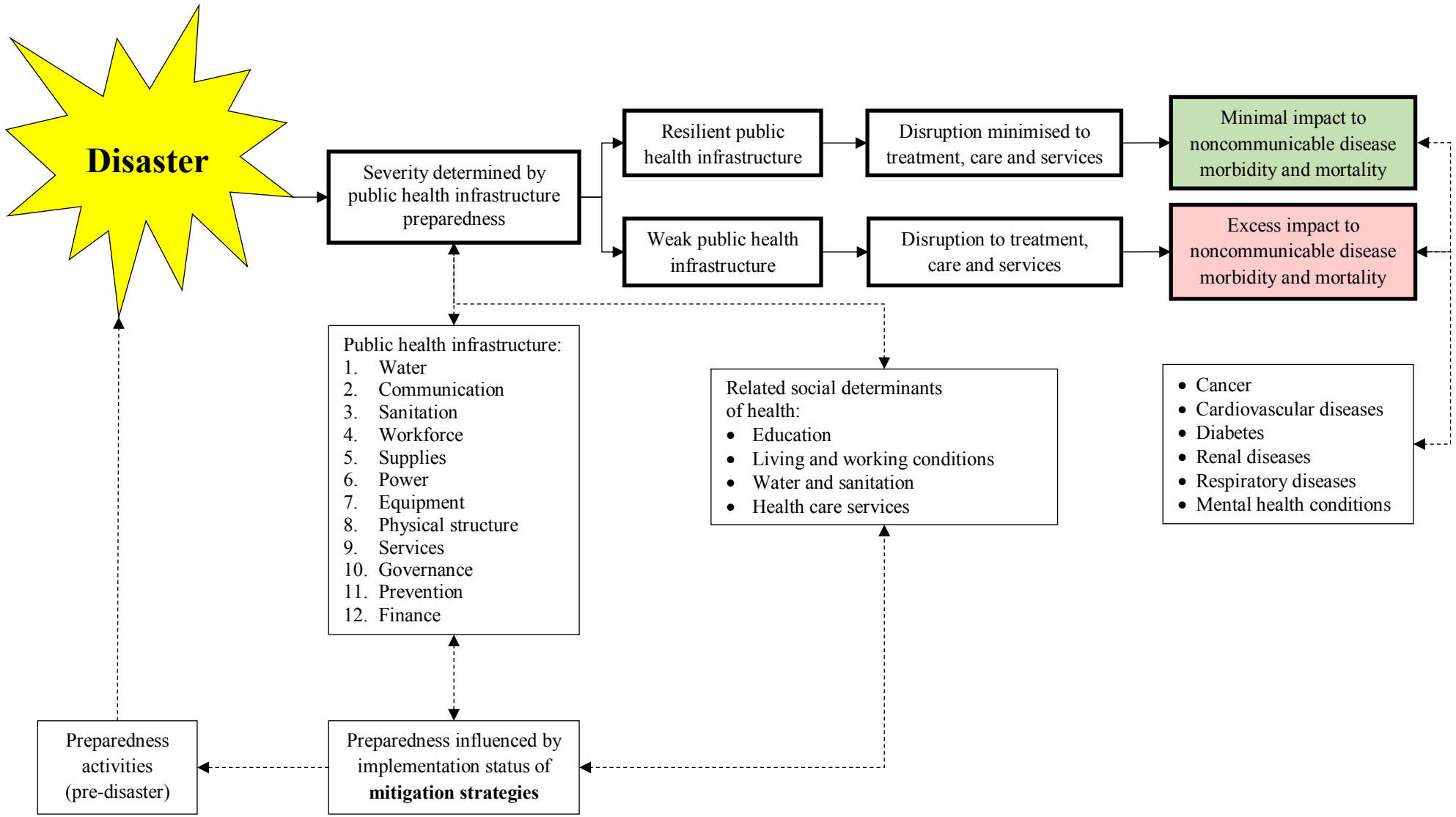

Figure 6-1 Conceptual framework

The mitigation strategies identified by this research[11] can be implemented across the disaster management phases of prevention, preparedness, response and recovery (Table 6-1).[13] Prevention activities should include: health services designed to mitigate against future disasters; and effective town planning (for example, locating services away from storm surge areas). Disaster preparedness for health should include: ensuring water treatment plants have back-up power; general practitioners having plans in-place to resume services immediately after a disaster; interagency planning for maintaining treatment, care and services; encouraging personal responsibility for disaster preparedness; and streamlining processes for patients to access medication after a disaster. Response activities for people with NCDs from a health sector perspective should include: rapid deployment of health professionals and medication to areas impacted by a disaster along with government officials to provide financial support. For recovery, activities should include: health professionals visiting evacuation centres and other mass gathering locations; systems in-place to allow people with NCDs to return home as soon as possible after a disaster; and access to tradespeople to maintain equipment and physical structures.

Table 6-1 Example of mitigation strategies across disaster management phases

Disaster management phase	**Example mitigation strategies**
Prevention	Health services designed to mitigate against future disasters (disaster resilient)
	Effective town planning (e.g. locating services away from storm surge areas) to reduce the vulnerability of health services to a disaster
Preparedness	Ensuring water treatment plants have back-up power
	General practitioners having plans in-place to resume services immediately after a disaster
	Interagency planning for maintaining treatment, care and services
	Encouraging personal responsibility for disaster preparedness
	Streamlining processes for patients to access medication after a disaster

Response	Rapid deployment of: - Health professionals - Medication to areas impacted - Government officials to provide financial support
Recovery	Health professionals visiting evacuation centres and other mass gathering locations Systems in-place to allow people with NCDs to return home as soon as possible after a disaster Access to tradespeople to maintain equipment and physical

The mitigation strategies and PHI identified[3,11] are aligned with the social determinants of health. This includes the conditions of: education; living and working conditions; water and sanitation; and health care services (Table 6-2).[14] For this reason, a key success factor for the mitigation strategies, and conceptual framework, is strong, supportive, and aligned leadership to guide and monitor application of the social determinants of health.[22] This applies to all leaders in the government, non-government and private sectors who have a role implementing the social determinants of health. For example, education departments should include disaster preparedness in their curriculum, those who provide housing make tenants aware of surrounding disaster risks, water and sanitation service providers prioritising vulnerable populations and health care services focus on meeting the needs of people with NCDs before, during and after a disaster.

Many of the drivers that influence NCD exacerbation before, during and after a disaster lie outside the direct responsibility of the health sector.[23] To cover this challenge, leaders in the government, non-government and private sectors must understand that NCD morbidity and mortality post disaster can be influenced by the conditions which people work, live, and age, and the wider set of forces that influence daily life such as economic policies, development agendas, social norms, social policies and political systems.[24] Strategies for integrating these conditions into regular social determinants of health activities are outlined in Table 6-2 and implementation will require a collaborative governance approach due to the range of sectors and agencies directly and indirectly involved (see 6.3.2).[25,26,]

Table 6-2 Mitigation strategies alignment with social determinants of health

Social determinant	**Disaster relationship**	**Mitigation strategy**
Education	Low level of education associated with higher risk NCD[15-17]	Encouraging personal responsibility for disaster preparedness People with NCDs having back-up equipment (for example, spare oxygen cylinders) Patients having a list of emergency contacts
Living and working conditions	People in poor living and working conditions more likely to have a NCD and unable to get through a long disaster response and recovery period without support[18-20]	Rapid deployment of health professionals to areas impacted by a disaster Rapid deployment of government officials to provide financial support Town planning to reduce the vulnerability of health services to a disaster Designated primary healthcare hubs post disaster
Water and sanitation	Breakdown in water and sanitation standards increases risk of NCD exacerbation (for example, safe water for dialysis) and exposure to harmful substances[1,21]	Water treatment plants with back-up power People with NCDs have access to at least three days' worth of safe water Good hygiene practices implemented at evacuation centres and shelters Food businesses maintaining good hygiene standards Community-wide messages about the need to maintain good hygiene practices in the home environment
Health care services	Disruption to treatment, care and services increases the likelihood NCD exacerbation or even death[1]	Streamlining processes for patients to access medication after a disaster General Practitioners having plans in-place to resume services immediately after a disaster Health services designed to be disaster resilient

When applying the conceptual framework, it is important for disaster and health planners to understand individual treatment, care and service needs. Maslow's hierarchy of needs provides a guide (Table 6-3).[27] For example, a lack of appropriate care for even a short period of time puts the health and wellbeing of people with NCDs at risk.[28,29] This is because people with NCDs are more vulnerable than others to the stresses and disruptions of a disaster.[30]

Table 6-3 Overview of Maslow's Hierarchy of Needs[31]

Goal (basic need)	**Definition**	**Example**
1. Physiological needs	Basic survival needs	Breathing, homeostasis, water, sleep, food, sex, clothing, shelter, mobility
2. Safety needs	Freedom from harm	Life, injury, threats
3. Social needs	Relationships	Communication, privacy, companionship, mental health, belongingness, role
4. Esteem needs	Image	Respect, self-worth, status
5. Self actualisation	To become everything that one is capable of becoming	External recognition, self-fulfillment

The basic survival needs outlined by Maslow, which include water, food and shelter are imbedded within the framework.[31] Water is the most important PHI, food is part of the supplies theme and shelter is encompassed by physical structure. Safety and belonging needs are also reflected throughout the framework, for example in the themes of communication, finance, governance, services and workforce. Although the approach of the framework is not a clear linear progression, it offers a multilayered model where disaster management activities can effectively meet the needs of people with NCDs before, during and after a disaster.[31]

6.3 Implementation of mitigation strategies

6.3.1 *System-wide change*

A system-wide change is required to ensure disaster and health systems can sustainably mitigate the impact of disasters on people with NCDs. The urgency for this to occur continues to accelerate due to climate change, deforestation and rapid urbanisation in disaster prone areas, global population aging, increasing obesity and decreasing physical activity.[32-35] The challenge is to broaden the focus of disaster management activities for health from response and recovery to a more proactive approach which emphasises prevention and mitigation.[36] System-wide change requires support and encouragement from decision-makers, clinicians, nurses, allied health professionals and those working in the non-acute sector.[37-40]

In an attempt to stimulate system-wide change the UNISDR Office for Northeast Asia and Global Education and Training Institute partnered with the Northern Queensland Primary Health Network, Australia, to deliver disaster workshops.[40] This was a good start by bringing together primary healthcare providers, disaster professionals and other health stakeholders to explore and discuss opportunities to include this sector in prevention, preparedness, response and recovery activities. However, further work is required to ensure the disaster and health systems, including the primary healthcare sector, can sustainably meet the treatment, care and services needs of those with NCDs before, during and after a disaster.[41,42]

Another consideration for system-wide change is the ability to share information across agencies about people with NCDs. This would help disaster and health planners effectively prepare for disasters. There are ethical considerations, such as maintaining confidential personal information, and community willingness to participate.[10] For example, vulnerable persons registers in Australia (people with NCDs generally included) are voluntary and are maintained by local governments.[43] This often results in an underestimate of the people at risk, for example, there are less than 1,350 registered as vulnerable in Victoria, Australia, from a population of just under six million.[44,45] However, this voluntary approach has value as it reflects people who believe they are most vulnerable and provides an indication of those likely to cooperate in an evacuation. Despite this, further information is required to ensure more accurate figures on the number of people at risk from a disaster. To achieve this, an integrated

system must be implemented to allow local healthcare providers to provide information about patients (with consent) at risk to local disaster and health planners.[10]

6.3.2 *Collaborative governance*

A collaborative governance approach is recommended to implement the mitigation strategies. Using a collaborative governance approach allows for engagement of local expertise and knowledge thus addressing local needs and issues. It includes the government, non-government and private sectors working together to solve a problem.[46] This approach is recommended due both to the complexity in mitigating the impact of disasters on people with NCDs and the range of sectors, organisations and disciplines involved in disaster management. For example, the highest post disaster priority identified by this research was access to water but the service delivery controls are not generally part of the health sector.[11] Water supply in Queensland is predominately provided by local government with support from business and other agencies to treat, transmit or reticulate potable water with any issues relating to safety/contamination generally monitored by the state health department.[11] There is also a risk that mitigating the impact of disasters on people with NCDs may not be seen as a priority by agencies outside health. This is due to the complex drivers that influence NCDs, which may not be obvious to professionals outside the health sector. Further demonstrating the need for cross-sectoral planning at a whole of government level, which is the foundation of collaborative governance.[46]

The collaborative governance approach would commence with disaster system leaders articulating the need to participate in the interests of people with NCDs and risk of disasters (incentive to participate).[11] It would be an amalgamation of organisations beyond the current disaster management system (government agency focus) to allow community and private organisations such as universities, primary healthcare sector (general practitioners and pharmacies) and transport companies to help solve this problem.[25] To achieve this there would be: face-to-face dialogue; engagement in comprehensive and shared planning; formal communication across multiple levels; and pooling and jointly acquiring resources to implement the mitigation strategies. [11, 26]

Achieving a collaborative governance approach would reflect the emerging risks, diversity and intensity of recent disasters.[47] For the prevention and preparedness phases this could include gathering data to understand the NCD profile (including those who are dependent on others to

maintain their condition), review of health service (including facility) disaster readiness, drug stockpiles and arrangements in-place to support patient-tailored disaster preparedness plans.[48] The response and recovery phases could include measuring PHI preparedness for people with NCDs such as communication, equipment, supplies, transport and the workforce.[10] This would be supplemented by mapping service provision, supporting primary health care, circulating information about service availability and promoting self-care.[48]

The collaborative governance approach outlined would also reflect the principles of inter-sectoral collaboration by engaging sectors beyond health and complement the comprehensive, all hazards, all agencies approach to disaster management in Queensland, Australia.[26,49,50] Achieving this would be a credible step towards situating the mitigation strategies within the disaster system, which is vital for sustainable change (see 6.3.6).

6.3.3 *Environmental health expanding disaster related activities to include NCDs*

It is the interdisciplinary characteristics of environmental health and the indirect, but vital, role in maximising treatment, care and services for people with NCDs that demonstrates the profession is an essential resource in helping address this problem.[9] In a disaster situation, particularly in Queensland, Australia, the profession works with and across disciplines to address risks relating to: drinking water; hazardous; general waste; sanitation; food safety; communicable diseases; vector issues; and mass gatherings.[51,52] All provide an indirect, but vial, role in maximising treatment, care and services for people with NCDs before, during and after a disaster.[35,54,53]

The desire to broaden the disaster management focus of the environmental health profession to include NCDs may on the surface appear to be idealistic. However, this change could be easily achieved by building on existing roles in the disaster setting, which includes monitoring and assessing public health risks before, during and after a disaster.[9] An authentic trespassing of professional boundaries would be required to achieve this change.[9] This may initially result in push-back from other professions but should, for example, include a team of clinicians, engineers and environmental health professionals working together to prepare for and respond to disasters.[54] A small professional change but a major expansion in focus for disaster and health systems considering the environmental health profession has little or no designated role in mitigating the impact of disasters on people with NCDs.

National and global leaders in environmental health and disaster management, such as the International Federation of Environmental Health and National Environmental Health Association (USA), must recognise this need to expand. This could be achieved by actively seeking involvement in developing local, national and international strategies to address the challenges faced by NCDs complemented by lobbying governments to expand the scope practice.[9] The *Sendai Framework for Disaster Risk Reduction 2015-2030* (Sendai Framework) provides a platform for this to occur as all United Nations member countries have signed up to this agreement. Statement 30(k) of the Sendai Framework states that NCDs need to be included in the design of disaster policies and plans.[6] Specific environmental health measures may include interweaving and cross-cutting disaster strategies such as protecting equipment/infrastructure, mapping vulnerabilities within a community and supporting/facilitating distribution of medicines.[1,55-57] This would provide services that help protect the health and wellbeing of people with NCDs before, during and after a disaster.

6.3.4 *Enhancing the role of primary healthcare in disaster management*

The role of primary healthcare in disaster management must be enhanced to sustainably reduce the impact of disasters on people with NCDs. The mechanism for this exists in the Queensland, Australia, *Disaster Management Act 2003* (the Act). Under the Act, Queensland Health through Hospital and Health Services (HHS) is primarily responsible for managing the health service related aspects of events within their area, which includes working with primary health networks (PHN), private sector and other stakeholders.[58] However, the primary healthcare sector is coordinated by the Australian Department of Health through PHNs and there has been little direction on their role in disaster management or funding allocated.[59] State health departments are responsible for HHSs but have no authority over PHNs (who do not represent all general practitioners).[60,61]

To enhance the primary healthcare sector involvement in disaster management, clarification on its role must be provided by the Australian Department of Health. Currently, this is not clearly defined, however, primary healthcare providers are based in the community and deliver the majority of treatment, care and services for people with NCDs.[40,62,63] In addition, primary healthcare is predominately delivered by small businesses and their needs to be a financial incentive to operate during and after a disaster. Based on this and the mitigation strategies identified during the research, it is recommended the PHNs in Queensland be directed by the

Australian Department of Health to include disaster management in their functions. This would include liaison and active engagement across the disaster cycle with primary healthcare providers, Department of Health (Queensland), HHSs, Local Disaster Management Groups (LDMG) and District Disaster Management Groups (DDMG).

The PHN role in disaster management can easily be integrated into the disaster prevention, preparedness and recovery phases. For example: prevention could focus on identifying and mapping disaster risks (flooding and storm surge) for primary healthcare facilities, pharmacies and hospitals where acute and ongoing care is provided including preventative treatment and health education; preparedness should focus on exercises, planning activities and reviews of disaster responses to ensure systems are in place to rapidly meet the needs of people with NCDs; response could focus on supporting the HHS, LDMG and DDMG with regular daily updates on general practice and pharmacy needs and services; and recovery activities would include running recovery working groups on identified priorities and contributing to community forums, newsletters and helping distribute information on behalf of the HHS, LDMG and DDMG.

A range of enablers would need to be implemented by the Australian Department of Health to enhance the role of primary healthcare sector in disaster management. The enablers would include: requiring representation of general practitioners at HHS, LDMGs and DDMG meetings and operations centres (for example, a professional organisation representative and/or a PHN nominee); financing and funding opportunities for primary healthcare providers involved in disaster management; and supporting PHN's by having this work as part of their remit. This would provide a foundation for ensuring a consistent and clear approach across the health sector, support implementation of the Sendai Framework, and most importantly, help reduce the impact of disasters on people with NCDs.

6.3.5 *Integration into performance and monitoring during non-disaster periods*

A focus on mitigating the impact of disasters on people with NCDs should be integrated into performance and monitoring during non-disaster periods.[64] This could include, for example, identifying locations for back-up treatment, care and services, working with primary healthcare facilities to design a hub model of care post disaster and financial and legislative incentives from state health departments and the Department of Health (Federal).[64] For this to occur,

mitigation strategies should be incorporated into existing national standards such as the Australian Commission on Safety and Quality in Health Care National Safety and Quality Health Service Standards.[65] Within this standard Action 1.10 relates to risk management, including disaster management plan, and would be the best place for the mitigation strategies to be incorporated.[65] This would ensure integration of the strategies into the hospital and health service accreditation cycle, budgets and business/strategic plans. If adopted, this approach would also help ensure PHI can withstand disasters, increase efficiency and the reliability of treatment, care and services, and ensure ongoing care of people with NCDs is integrated into system-wide policies, plans, programs and budgets.[66]

A scorecard for PHI disaster preparedness would provide a complementary mechanism for integrating the mitigation strategies into practice. This could be mandated through legislation, financial incentives or directives by state health departments and the Australian Department of Health to HHSs with support from PHNs and LDMGs. This would allow disaster and health planners to work collaboratively to identify and understand the level of readiness to meet the needs of people with NCDs before, during and after a disaster.

The UNISDR Disaster Resilience Scorecard for Cities (UNISDR Scorecard) provides a template for developing a PHI disaster preparedness scorecard. It is a set of assessments currently used by local governments to monitor and review progress and challenges in the implementation of the Sendai Framework and assess their disaster resilience.[67] The scorecard levels (based on the UNISDR Scorecard) could have a preliminary level 1 assessment for each PHI theme with a score of 0-3 (0 not in-place; 3 complete Disaster Risk Reduction plan/strategies in-place). This could be followed by a more detailed assessment at level 2, which analyses the mitigation strategies by PHI theme using scoring of 0-5. Completion of the scorecard would be led by HHSs with support from PHNs and LDMGs. If adopted, application of such a scorecard would provide a systems-based understanding of disaster risks for PHI and priority areas of improvement to maintain treatment, care and services for people with NCDs.

6.3.6 *Situating the findings*

6.3.6.1 Australian context

The impact and value of this research will be significant for people with NCDs and the disaster and health systems not only in Queensland but also in areas across Australia at risk of cyclone,

flood and storm related disasters. This is because in Australia, NCDs cause approximately 90% of all deaths, account for 88% of the burden of disease and are responsible for 83% of recurrent health expenditure.[68,69] The mitigation strategies, if implemented, will particularly benefit people with cancer, cardiovascular diseases, diabetes, mental health conditions, respiratory conditions and renal disease.[70] These conditions are at greatest risk post disaster and are long-lasting, placing great burden on patients, health services and fiscal systems not only in the state of Queensland but across Australia.[71,72]

The research findings are relevant for those in remote, rural and remote areas of Queensland. This is because as the distance from major cities and regional centres increases, the NCD burden increases while the ease of access to treatment, care and services decreases.[73] Natural disasters are also a feature of the climate and landscape in Queensland and are anticipated to increase, with climate change expected to make extreme weather events such as cyclones, floods and storms more frequent.[74-76] Recent examples of extreme weather events include Severe Tropical Cyclone Larry (2006); flash flooding in the Lockyer Valley (2011); Severe Tropical Cyclone Yasi (2011); flooding in Bundaberg (2013); Tropical Cyclone Nathan (2015); and Severe Tropical Cyclone Debbie (2017).[74]

The mitigation strategies presented are situated in the comprehensive all hazards and all agencies approach to disaster management.[77,78] This approach is important in Australia because prevention, preparedness, response and recovery activities of the disaster cycle are delivered through partnerships with all agencies, organisations and communities.[78] This approach, and applicability of the findings, provides disaster and health planners with a mechanism for understanding how PHI preparedness can reduce the impact of disasters on people with NCDs. Providing a platform to ensure future disaster strategies can reflect the recent epidemiological transition from communicable diseases to NCDs.

6.3.6.2 International context

The Sendai Framework item 30(k) ensures the findings are situated in the international context. Item 30(k) requests that people with chronic diseases (also known as NCDs) are included in the design of policies and plans to manage their risks before, during and after disasters.[66] This reinforces the United Nations resolution 70/1 *Transforming our world: the 2030 agenda for sustainable development*[79], which refers to NCDs (Goal 3.4) and disaster risk reduction (Goal 11.5), and WHO *Global Action Plan for the Prevention and Control of Noncommunicable*

Diseases – 2013-2020.[80] The World Economic Forum (WEF) also regularly ranks NCD risks to worldwide disruption on par with fiscal crisis, which is only exceeded by the impact of an asset price collapse, or the increase in oil and gas prices.[81] This is supported by the WHO report *Scaling up action against noncommunicable diseases: How much will it cost*, in which concerns about the escalating global burden of NCDs are described as not being just an epidemiological issue but economic.[82]

The main features of the Sendai Framework include a shift in focus from managing disasters to managing risks and a strong focus on health with the word mentioned 38 times, including references to NCDs, compared to three in the predecessor the Hyogo Framework for Action.[66] This shift in focus requires a better understanding of risk in all its dimensions of vulnerability, exposure, hazards and probability, while also focusing on reducing mortality, population wellbeing, early warning and promoting disaster preparedness of health facilities and hospitals.[83] This research has supported this through describing the impact cyclone, flood and storm related disasters have on PHI and the subsequent management of NCDs, which informed development of the mitigation strategies.[9-11, 69, 84]

The findings add value to disaster and health systems across the world in low, middle and high-income countries by providing a mechanism for understanding how PHI preparedness can reduce the impact of disasters on people with NCDs. Almost three quarters of all NCD deaths, and 82% of people who die prematurely (before reaching 70 years of age), occur in low- and middle-income countries.[11,85] As in Australia, population ageing along with changes in lifestyle, increasing obesity and overweight, decreasing physical activity, environmental change and reduction in communicable disease in populations across the world has contributed to a disease transition to NCDs.[35-38] Also, lower-income countries generally have limited capacity to provide care and treatment for people with NCDs compared with high-income countries.[86] The result is an increased risk of NCD exacerbation or even death post disaster.[9] In addition, the conceptual framework also provides a mechanism for engaging local expertise and knowledge thus addressing local needs and issues in various contexts around the world.

The research findings provide benefits for interdisciplinary fields related to medicine, public health and education. The conceptual framework along with the mitigation strategies provides professionals in these fields with a theoretical mechanism for understanding how PHI preparedness can reduce the impact of disasters on people with NCDs. The mitigation strategies

can also be implemented within and across professions. This is because of the direct and indirect role different professions have in treating and caring for people with NCDs.[9] For example, the environmental health profession often oversees the safety of drinking water, which is required for dialysis treatment and hydration. By understanding and recognising the conceptual framework, the fields of medicine, public health and education can ensure future disaster strategies are interdisciplinary and meet the treatment, care and service needs of people with NCDs.

6.4 Future considerations

There are a range of considerations required to ensure disaster and health planners can implement the mitigation strategies and meet future health challenges. These include: understanding the impact of comorbidities; increased data and evidence on NCDs before, during and after disasters; and evaluating the effectiveness of the mitigation strategies.

6.4.1 *Comorbidities*

People with NCDs and their risk of comorbidity post disaster requires further investigation. This increased comorbidity risk could be induced by damage to property, loss of livelihood and disrupted access to treatment, care and services, which can lead to emotional distress, higher blood pressure and exposure to unsanitary conditions.[88] Diabetics may be at an increased risk post disaster of posttraumatic stress disorder, myocardial infarction and infection.[89,90] Drug users and people in addiction treatment programs are another consideration.[10] Shelters and evacuation centres are often ill equipped to meet the needs of these people as they are designed predominately to cater for the healthy.[89] This can result in increased pressure on emergency departments to provide dosing while dealing with an influx of patients requiring acute care.[90]

The impact of disasters on people with arthritis and obesity must also be considered due to the increased demand and complications this can create for emergency services post disaster. For example, a study targeting patients with arthritis in Japan found 46% of participants had a personal stockpile of medications but only 53% carried medication all the time and 25% had an emergency kit.[91,92] This is a concern because arthritis patients generally require continuous treatment and without this flare-ups can occur resulting in a deteriorating functional status.[91] For people with obesity a disaster can also cause severe complications because in

normal situations treatment, care and services requires increased resources such as personnel, supplies, and specialist mobility equipment.[93-95] This issue has led some United States relief organisations requiring special-needs shelters to accommodate people with obesity.[95]

Post disaster comorbidity research would require partnerships between operational and academic agencies to ensure high-quality evidence could be generated. This approach is particularly important due to the complex and inter-disciplinary nature of comorbidities in the disaster setting. Completion of such research would provide an effective foundation to improve the effectiveness and feasibility of not only NCD care in disasters but associated comorbidities and risks.

6.4.2 *Increased noncommunicable disease data post disaster*

There is a need for more data and analysis because the actual impact of disasters on people with NCDs remains unknown. For example, uncontrolled diabetes for extended periods can result in heart disease (heart attacks and strokes), blindness, kidney failure and lower-extremity amputations.[96-99] However, for diabetics and people with other NCDs there is limited data on the long-term health complications associated with a disruption to treatment management and care due to a disaster. After Hurricane Katrina 33% of people exhibited symptoms of chronic disease exacerbation when arriving at shelters and one year later there was a 33% reduction in cancer treatment services due to damage and destruction.[1,100,101] Other examples include: an increase by 19% of cancer related deaths in the 12 months after Hurricane Iniki (1992) and the weeks after Florida's four hurricane's in 2004[102,103]; 5% of excess deaths after the four Hurricane's in Florida were attributed to diabetes [101,104]; and cardiac mortality increased by 31% and incidence by 22% in the 30 days after Hurricane Sandy (2012).[105]

A data analysis could be a solution by providing validation on the NCD trends and priorities post disaster. This could be achieved by expanding the methodology used by Aitken et al (2015) to describe a spike in patient presentations to the Emergency Department (ED) of a tertiary level hospital (Townsville) following a tropical cyclone (Yasi).[106] Specific areas of focus could include changes in: patient demographics (age and gender); triage categories; and classification of diseases over a three month period (commencing one week before the disaster) in comparison to previous years in hospitals that have been impacted by a similar disaster type.

This would provide much needed knowledge on disaster affected populations and allow NCD priorities to be identified and validated.

6.4.3 *Evaluate effectiveness of mitigation strategies*

The mitigation strategies provide a theoretical mechanism for reducing the impact of disasters on people with NCDs. For this reason following implementation there would need to be an evaluation of the mitigation strategies.[11] A process for achieving this could be describing patient presentations to the Emergency Department of a tertiary level hospital at sites with the mitigation strategies in-place with a focus on: patient demographics (age and gender), triage categories, and classification of diseases.[106] This could be complemented by long term cohort studies and cluster samples in rapid needs assessments after a cyclone, flood or storm related disaster, which could be generalised to a larger population.[107]

The evaluation could also look at cost effectiveness not only for health systems but individuals and their long-term health outcomes. For example, after Hurricane Katrina the lifetime cost for public diabetes patients was estimated to increase by US$5,243, US$3,907 for Veterans Affairs patients and US$2,270 for privately insured patients.[108] This increase can be attributed to costs of diabetes related complications due to the treatment disruptions.[8,108] Evaluating this impact could help understand financial and long-term implications for individuals, the community and health systems.

Further work also needs to be undertaken to develop an evidence base to understand the effectiveness of all mitigation strategies and their ability to improve or maintain the health and wellbeing of people with NCDs in disaster and non-disaster periods. A life course approach to NCD epidemiology may provide a template for such research to be completed.[109] This could include research on the long-term effects of NCD risk based on exposure to disasters in areas with and without mitigation strategies during gestation, childhood, adolescence, young adulthood and later life.[110] If achieved, this would help to understand if disaster exposure influences development of NCDs and explain disease distribution patterns across geographical and social areas impacted by disasters.

6.5 Limitations

The research was the first of its kind to investigate the impact of cyclone, flood and storm related disasters on PHI and the management of NCDs, and develop strategies for mitigating the risks identified. As with any new research area a number of lessons were learnt. While expressed as limitations in the following they need to be understood in the context of this novel research, which provides a platform to start mitigating the impact of disasters on people with NCDs.

6.5.1 *General*

The research area was limited to, Queensland, Australia. This is a large geographical state (second largest in Australia), with a decentralised population and is regularly exposed cyclones, floods and storms.[111,112] Subsequently, caution is urged when applying the findings to other disaster types. However, this is also a strength because the findings can be transferred to the same disaster types across the world where there are similar disease burdens/trends but caution is urged as all systems are unique.

The lead author's studies and work in public health and disaster management in Australia at local, state and national levels and across the Asia-Pacific, Europe and North America influenced the research direction. Also, the researcher was situated in the qualitative aspects of the research (interviews, focus group and workshop). To mitigate this limitation, the supervisory panel assisted with the study design, reviewed the thematic analysis, challenged the approach, and provided critical feedback and input during the research.

Completing the research in one language, English, may have resulted in some people in the research area not participating. However, the impact on the overall results can be considered minimal because only 1.1% of the Queensland population speak a language other than English at home and do not speak it well or not at all.[113]

The research was limited to a high-income country setting. This potentially limits transferability of the findings to low and middle-income countries because the PHI, disaster system and NCD priorities and challenges may differ.

The use of literature reviews, focus groups, interviews and a modified Delphi process to gather data and interpret the findings may raise "dilemmas of method". This juxtaposition of sociology, where the researcher observes and analyses similarities and differences side-by-side, was constrained by the underlying aim and objectives.[114] Also, the research did not focus on similarities and differences at macro or micro levels negating "dilemmas of method". A sequential and triangulation methodology was used to ensure the findings from this novel and complex research area were informed and developed throughout using various methods. This approach allowed the researcher to focus on a process that had distinct sequential steps occurring chronologically over time.[115]

The modified Delphi process can have challenges surrounding problem identification, researcher skills and data presentation.[116] These challenges were not considered a limitation as the third phase of the research required the Delphi process. There was a need for informed judgements across disciplines along with education on the interrelated aspects of developing and implementing mitigation strategies for reducing the risk of disaster exacerbated NCDs.[116] Researcher skills and data presentation were not an issue due the experienced supervisory panel providing critical feedback and input throughout the research.

6.5.2 *Disasters experienced*

The severity of the disaster experienced among participants may have varied. For example, some participants who indicated they were impacted by a cyclone may not have had the eye of the system cross over where they were based and therefore the deterioration in access to treatment, care and services experienced may have varied. There may also be disaster service providers who worked in areas that were more impacted by a disaster than other locations. Careful consideration should be taken to the scale of the disaster expected/impact when applying the findings.

The severity a person's NCD and status of treatment may have varied between disasters experienced. For example, a participant could have been undergoing chemotherapy treatment at the time of one disaster and not another. This limitation recognises the individual treatment, care and services needs with NCD grouping before, during and after a disaster and must also be considered when applying the findings.

Recall bias was a limitation for this study.[115] There were participants who had experienced disasters in the past two years while it may have been longer for others. The impact of this recall bias should be considered minimal as a disaster is a significant event in life, increasing the likelihood of the event being committed to memory. Also, the sequential and triangulation methodology used for the study ensured the findings were informed and developed throughout the research using various methods.

Convenience sampling was used for interviews, focus groups, and the questionnaire and workshop phases of the modified Delphi process.[118,119] This limitation demonstrates the findings may not be representative of the general population, particularly for those with NCDs. For example, the research participants may have had greater access to resources to participate, better education or knowledge, social support or even access to research sites.[120] However, advantages of this sampling procedure include participant availability, increased ease of participation and the speed data could be collected for analysis.[121] This approach should be considered advantageous for this novel research area because the aim was to maximise participation and provide an evidence base for reducing the impact of disasters on people with NCDs. To mitigate the impact this may have had on the research, there was wide distribution of the survey. This maximised the opportunity for diverse populations across the research area to participate in the final phase of the study.

6.5.3 *Disaster service providers*

The research was limited to disaster service providers in Queensland, Australia, who have predominately prepared for, and responded to, cyclones, floods and storms in Australia. This group was primarily from government agencies, which can limit the perspective provided. However, this group generally has legislative and functional roles in disaster management that are vital in influencing the impact of disasters on PHI and maximising treatment, care and services for people with NCDs. This includes working with other sectors such as business and non-government organizations. Due to the variety of disaster service providers who participated and their experience, the impact on the research narrative and relevance is minimal. For this reason, it is proposed the findings can be transferred to the same disaster types across the world where there are similar disease burdens/trends and disaster systems.

The selection of environmental health as the only targeted profession for the focus group phase was a potential limitation. This is because their perspectives may have been primarily developed from practice in this domain, potentially limiting the understanding of the indirect role their work has in supporting treatment and care for people with NCDs. This limitation was overcome by integrating the results with findings from focus groups and interviews with disaster service providers and people with NCDs. The integrated results were then used to inform the modified Delphi process, which minimised the impact on the research narrative. In addition, there was a need to focus on this profession because it works across and with disciplines to address risks relating to: drinking water; hazardous substances; general waste; sanitation; food safety; communicable diseases; vector issues; and mass gatherings.[51,52] Activities that can be considered vital for maintaining the health and wellbeing of people with NCDs.[35,54,53]

Responders provided the greatest number of mitigation strategies. This likely reflects the on-the-ground disaster experience and training of responders. Also, this reflected the aim of the interview and focus group phase, which was to maximise the number of mitigation strategies identified from all participants. Any limitation this may have had was minimised by the modified Delphi process were people with NCDs and a broad range of disaster service providers were able to rank and prioritize mitigation strategies.

6.5.4 *Noncommunicable diseases*

This research primarily focused on the NCDs of: cancer; cardiovascular diseases; diabetes; mental health conditions; respiratory diseases; and renal diseases. While this did not cover all NCDs it not only allowed the conditions at greatest risk post disaster but those that are also long-lasting, which place great burden on patients, health services and fiscal systems in Queensland[68,70] For example, cancer accounts for 17% of disease burden in Queensland, cardiovascular disease 14%, mental health conditions 12%, diabetes 10% and renal diseases 1%.[122] More broadly, NCDs cause approximately 90% of all deaths in Queensland and account for 88% of the burden of disease and are responsible for 83% of recurrent health expenditure (these trends are similar across Australia).[68,71] However, other NCDs may be impacted by a disaster and caution should be taken in applying the results to other NCDs.

People with NCDs were not requested to rank and prioritise mitigation strategies. The authors selected this approach to maximise the number of people with NCDs who could complete the survey by reducing the time required to participate. The impact is considered minimal by the authors, as people with NCDs were involved in earlier research (interviews and focus groups) that focused on developing mitigation strategies. In addition, there were opportunities in the survey to add free text comments and predominately disaster service providers are responsible for leading implementation of the mitigation strategies identified.

There was no large sample size in any grouping and therefore results for each NCD should be accepted with caution. These include the fact that the number was low for the interviews, which creates the possibility of making inaccurate predictions or assumptions and that different results could be generated from a larger study.[123,124] However, it should be noted the point of saturation was reached after interview 11. Also, this approach was selected to validate proposed strategies for solving this problem for the first time from a patient perspective. To increase the transferability of the survey findings the authors grouped the results for all NCDs when conducting the analysis.

The research did not actively explore people with different levels of cognitive function and drug users. As a result, the findings, particularly as they relate to people with mental health conditions and drug users should be accepted with caution. It should be noted the intention of this study was not to explore different levels of cognitive function or drug users.

6.6 Conclusion

Disasters can and do impact the PHI required to maintain treatment, care and services for people with NCDs. The result in an increased risk of acute exacerbation of NCDs, worsening long-term prognosis and even death. People with NCDs at greatest risk are those with underlying cardiovascular and respiratory diseases, undergoing cancer treatment, with unstable diabetes and mental health conditions, and with renal diseases. This risk is anticipated to continue, if not increase, due to an increasing NCD burden and climate change, deforestation and rapid urbanisation in flood plains and storm-prone coastal zones. To reduce this risk providing access to water should be first priority followed by implementation of the mitigation strategies related to communication, sanitation, workforce, supplies, power, equipment, physical structure, services, governance, prevention and finance. Implementation will require

a collaborative governance approach due to the range of sectors, organisations and disciplines involved in disaster management. Achieving this would not only support implementation of the Sendai Framework but also provide a sustainable approach towards reducing indirect mortality and morbidity from NCDs before, during and after a disaster.

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Chapter 7 Conclusion

The frequency of natural disasters and increasing noncommunicable diseases (NCD) burden across the world has created an urgent need for disaster and health systems to expand focus beyond immediate trauma and communicable diseases. Disasters can and do impact the public health infrastructure (PHI) required to maintain treatment, care and services for people with NCDs. The result is an increased risk of NCD exacerbation, worse long-term prognosis or even death. The people at greatest risk are those with underlying cardiovascular and respiratory diseases, undergoing cancer treatment, with unstable diabetes and mental health conditions, and with renal diseases.

This research identified strategies for mitigating the impact of cyclone, flood and storm related disasters on treatment, care and services for people with NCDs. This included 31 mitigation strategies across 12 PHI themes. Water was identified as the most important PHI theme. If this fails, it has the greatest impact on the health and wellbeing of people with NCDs. Once water issues are addressed, the remaining PHI and associated mitigation strategies can be progressively resolved, noting that some may need to be concurrently addressed to ensure delivery of water services. The next most important themes identified were communication followed by sanitation, workforce, supplies, power, equipment, physical structure, services, governance, prevention, transport, surveillance and finance.

PHI and the reciprocal mitigation strategies are interrelated and often if one component fails access to treatment, care and services for people with NCDs can be compromised. For example, it may not be possible to address water and sanitation issues without power, which may be reliant on supplies such as electrical lines that need be repaired post disaster by a workforce requiring equipment and transport into the affected theme. Response and recovery activities for each PHI theme can also occur in parallel as different professions and agencies have varying responsibilities (for example, power the responsibility of electrical companies and supplies logistics experts). Disaster and health planners must work with and across professions and agencies to ensure preparations and responses can meet the needs of people with NCDs. However, for this to be effective, the relationship between how NCD morbidity and mortality post disaster is influenced by the level of PHI preparedness and the subsequent access provided to treatment, care and services must be understood and reflected in disaster plans

This research incorporated the unique perspectives of people with NCDs to understand treatment, care and service needs before, during and after a disaster. This novel research provided a mechanism for helping deliver on section 30(k) of the *Sendai Framework for Disaster Risk Reduction 2015-2030* (Sendai Framework). Section 30(k) recommends that NCDs (referred to as chronic diseases) be included in the design of disaster policies and plans. The findings reinforce the WHO *Global Action Plan for the Prevention and Control of Noncommunicable Diseases – 2013-2020* and the United Nations resolution 70/1 *Transforming our world: the 2030 agenda for sustainable development* (Goal's 3.4 NCDs and 11.5 disaster risk reduction).

The sequential and triangulation research methodology allowed the findings to be chronologically verified and validated. This included: literature reviews; focus groups and interviews with disaster service providers and people with NCDs; a questionnaire and workshop phase with disaster health experts; and a survey distributed across Queensland, Australia. This process allowed: relationships between PHI and NCD management to be explored in detail; ongoing refinement and testing of emerging ideas; development and verification of new strategies; and enhanced generalisability of the findings. Leading to the development of a conceptual framework for addressing NCDs in a disaster context, this framework offers disaster and health planners a systematic process for understanding how to consider the needs of people with NCDs in the disaster preparation, response, and recovery phases.

A collaborative governance approach is proposed for implementation as there are a wide range of disciplines, organisations and sectors involved in caring for people with NCDs. This allows for engagement of local expertise and knowledge thus addressing local needs and issues. Such an approach should be an amalgamation of organisations beyond the current disaster management system (government agency focus) to allow community and private organisations such as universities, primary healthcare sector (general practitioners and pharmacies) and transport companies to help solve this problem. The process would include: engaging in comprehensive and shared planning; formal communication across multiple levels; and pooling and jointly acquiring resources to implement the mitigation strategies. This collaborative governance approach would complement the comprehensive all hazards and all agencies approach to disaster management used in Queensland, Australia.

Finally, disaster and health planners must consider the needs and challenges faced by people with NCDs across the disaster cycle. This will assist in better mitigating, from the standpoint of the patient, the anticipated risks of their health outcomes, acute exacerbations or complications, both during and post disaster. It is also vital to understand all mitigation strategies are interrelated and together along with the social determinants of health provide the conceptual framework required for addressing this problem. Implementation will require a collaborative governance approach due to the range of sectors, organisations and disciplines involved in disaster management. Achieving this would support implementation of the Sendai Framework and provide a sustainable approach towards reducing the impact of disasters on people with NCDs.

Appendices

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Appendix A: Publication 1 – Analyzing the impact of Severe Tropical Cyclone Yasi on public health infrastructure and the management of noncommunicable diseases

ORIGINAL RESEARCH

Analyzing the Impact of Severe Tropical Cyclone Yasi on Public Health Infrastructure and the Management of Noncommunicable Diseases

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Conflicts of interest: none

Keywords: chronic disease; cyclone; disaster; disaster planning; equipment; public health; public health infrastructure; water

Abbreviations:
NCD: noncommunicable disease
PHI: public health infrastructure
STC Yasi: Severe Tropical Cyclone Yasi

Received: June 2, 2014
Revised: October 7, 2014
Accepted: October 23, 2014

doi:10.1017/S1049023X1400137X

Abstract

Introduction: Traditionally, post disaster response activities have focused on immediate trauma and communicable diseases. In developed countries such as Australia, the post disaster risk for communicable disease is low. However, a "disease transition" is now recognized at the population level where noncommunicable diseases (NCDs) are increasingly documented as a post disaster issue. This potentially places an extra burden on health care resources and may have implications for disaster-management systems. With increasing likelihood of major disasters for all sectors of global society, there is a need to ensure that health systems, including public health infrastructure (PHI), can respond properly.

Problem: There is limited peer-reviewed literature on the impact of disasters on NCDs. Research is required to better determine both the impact of NCDs post disaster and their impact on PHI and disaster-management systems.

Methods: A literature review was used to collect and analyze data on the impact of the index case event, Australia's Severe Tropical Cyclone Yasi (STC Yasi), on PHI and the management of NCDs. The findings were compared with data from other world cyclone events. The databases searched were MEDLINE, CINAHL, Google Scholar, and Google. The date range for the STC Yasi search was January 26, 2011 through May 2, 2013. No time limits were applied to the search from other cyclone events. The variables compared were tropical cyclones and their impacts on PHI and NCDs. The outcome of interest was to identify if there were trends across similar world events and to determine if this could be extrapolated for future crises.

Results: This research showed a tropical cyclone (including a hurricane and typhoon) can impact PHI, for instance, equipment (oxygen, syringes, and medications), services (treatment and care), and clean water availability/access that would impact both the treatment and management of NCDs. The comparison between STC Yasi and worldwide tropical cyclones found the challenges faced were linked closely. These relate to communication, equipment and services, evacuation, medication, planning, and water supplies.

Conclusion: This research demonstrated that a negative trend pattern existed between the impact of STC Yasi and other similar world cyclone events on PHI and the management of NCDs. This research provides an insight for disaster planners to address concerns of people with NCDs. While further research is needed, this study provides an understanding of areas for improvement, specifically enhancing protective PHI and the development of strategies for maintaining treatment and alternative care options, such as maintaining safe water for dialysis patients.

Ryan BJ, Franklin RC, Burkle FM Jr, Watt K, Aitken P, Smith EC, Leggat P. Analyzing the impact of Severe Tropical Cyclone Yasi on public health infrastructure and the management of noncommunicable diseases. *Prehosp Disaster Med.* 2015;30(1):1-10.

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Appendix B: Publication 2 – Defining, describing and categorizing public health infrastructure for cyclone, flood and storm related disasters

ORIGINAL RESEARCH

Defining, Describing, and Categorizing Public Health Infrastructure Priorities for Tropical Cyclone, Flood, Storm, Tornado, and Tsunami-Related Disasters

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ABSTRACT

Objectives: The study aim was to undertake a qualitative research literature review to analyze available databases to define, describe, and categorize public health infrastructure (PHI) priorities for tropical cyclone, flood, storm, tornado, and tsunami-related disasters.

Methods: Five electronic publication databases were searched to define, describe, or categorize PHI and discuss tropical cyclone, flood, storm, tornado, and tsunami-related disasters and their impact on PHI. The data were analyzed through aggregation of individual articles to create an overall data description. The data were grouped into PHI themes, which were then prioritized on the basis of degree of interdependency.

Results: Sixty-seven relevant articles were identified. PHI was categorized into 13 themes with a total of 158 descriptors. The highest priority PHI identified was workforce. This was followed by water, sanitation, equipment, communication, physical structure, power, governance, prevention, supplies, service, transport, and surveillance.

Conclusions: This review identified workforce as the most important of the 13 thematic areas related to PHI and disasters. If its functionality fails, workforce has the greatest impact on the performance of health services. If addressed post-disaster, the remaining forms of PHI will then be progressively addressed. These findings are a step toward providing an evidence base to inform PHI priorities in the disaster setting. (*Disaster Med Public Health Preparedness*, 2016;page 1 of 13)

Key Words: disasters, public health, emergency preparedness, disaster planning

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Appendix C: Publication 3 – Identifying and describing the impact of cyclone, storm and flood related disasters on treatment management, care and exacerbations of noncommunicable diseases and the implications for public health

PLOS | CURRENTS DISASTERS

Identifying and Describing the Impact of Cyclone, Storm and Flood Related Disasters on Treatment Management, Care and Exacerbations of Non-communicable Diseases and the Implications for Public Health

September 28, 2015 · Research article

Citation

Ryan B, Franklin RC, Burkle FM, Aitken P, Smith E, Watt K, Leggat P. Identifying and Describing the Impact of Cyclone, Storm and Flood Related Disasters on Treatment Management, Care and Exacerbations of Non-communicable Diseases and the Implications for Public Health. PLOS Currents Disasters. 2015 Sep 28 . Edition 1. doi: 10.1371/currents.dis.62e9266d152de04799644dcca47d9266.

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Revisions

This article is either a revised version or has previous revisions
Edition 1 - September 28, 2015

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Abstract

Introduction: Over the last quarter of a century the frequency of natural disasters and the burden of non-communicable diseases (NCD) across the globe have been increasing. For individuals susceptible to, or chronically experiencing, NCDs this has become a significant risk. Disasters jeopardize access to essential treatment, care, equipment, water and food, which can result in an exacerbation of existing conditions or even preventable death. Consequently, there is a need to expand the public health focus of disaster management to include NCDs. To provide a platform for this to occur, this article presents the results from a systematic review that identifies and describes the impact of cyclone, flood and storm related disasters on those susceptible to, or experiencing, NCDs. The NCDs researched were: cardiovascular diseases; cancers; chronic respiratory diseases; and diabetes.

Methods: Four electronic publication databases were searched with a date limit of 31 December 2014. The data was analyzed through an aggregation of individual papers to create an overall data description. The data was then grouped by disease to describe the impact of a disaster on treatment management, exacerbation, and health care of people with NCDs. The PRISMA checklist was used to guide presentation of the research.

Results: The review identified 48 relevant articles. All studies represented developed country data. Disasters interrupt treatment management and overall care for people with NCDs, which results in an increased risk of exacerbation of their illness or even death. The interruption may be caused by a range of factors, such as damaged transport routes, reduced health services, loss of power and evacuations. The health impact varied according to the NCD. For people with chronic respiratory diseases, a disaster increases the risk of acute exacerbation. Meanwhile, for people with cancer, cardiovascular diseases and diabetes there is an increased risk of their illness exacerbating, which can result in death.

Conclusion: Cyclone, flood and storm related disasters impact on treatment management and care for people with NCDs. Possible consequences include exacerbation of illness, complications or even death. There is now a need to expand traditional disaster approaches by public health to incorporate NCDs. This must be guided by the major NCDs identified by the World Health Organization and implemented in-line with the Sendai Framework for Disaster Risk Reduction: 2015-2030. This includes understanding all the factors that influence both direct and indirect (preventable) morbidity and mortality related to NCDs during and after disasters. Once achieved, disaster planners and public health professionals will be in a position to develop and implement effective mitigation strategies.

Funding Statement

This research was part of doctorate studies at James Cook University, Australia. The research was supported by funding from the Australian Centre for Health Service Innovation and Cunningham Centre / Toowoomba Hospital Foundation, Australia. The Cairns and Hinterland Hospital and Health Service, Queensland, Australia, has provided in kind support.

Introduction

Over the past quarter of century there has been a global increase in the frequency and severity of disasters and burden of non-communicable diseases (NCD).[1,2] For example, since 2005 disasters have resulted in over 700 thousand deaths, over 1.4 million people being injured, approximately 23 million people homeless, 1.5 billion people affected and economic losses of more than $1.3 trillion.[3] Of the disasters worldwide cyclone, flood or storms have accounted for 88% and are responsible for 76% of disaster related deaths.[4,5] This threat is anticipated to continue, if not increase, with climate change expected to make extreme weather events, such as cyclones, floods and storms, more frequent and severe.[3,6,7] For individuals with NCDs this represents a significant risk because disasters jeopardize access to and often availability of essential public health treatment options, equipment, clean water and food, which can result in an exacerbation of existing conditions or even preventable death.[1,8,9,10,11,12,13,14]

This problem has been recognized globally by the United Nations in the Sendai Framework for Disaster Risk Reduction: 2015-2030 (Sendai Framework). Item 30(k) relates to chronic diseases (interchangeable with NCDs) and requests that due to their particular needs should be included in the design of policies and plans to manage risks before, during and after disasters, including having access to life-saving services.[3] This call to action builds on and compliments the World Health Organization (WHO) Global Action Plan for the Prevention and Control of Noncommunicable Diseases – 2013-2020 (WHO Action Plan).[15]

NCDs are prolonged illnesses, rarely cured completely and are not passed from person to person.[16,17] There are four major groupings: cardiovascular diseases; cancers; chronic respiratory diseases; and diabetes.[15,17,18] These conditions account for 79% of NCD deaths globally and have common behavioral risk factors (smoking, physical inactivity, poor nutrition and harmful use of alcohol).[15,17,18] Minor groupings within NCDs include arthritis, obesity, mental health and renal conditions.[16,17,18,19]

The risk disasters pose to people with NCDs is further highlighted by the traditional public health focus on communicable diseases following a disaster when the actual risk is low (particularly in developed countries).[20] Improvements in life expectancy along with changes in lifestyle and diet have contributed to a 'disease transition' from communicable diseases to NCDs.[1,17,21,22] NCDs are costly and time exhaustive to treat, which has implications for health systems' capacity and capability.[23,24] This impact is expected to rise over the coming decades as the prevalence of NCDs across the world increases, public health infrastructure is further compromised and economic pressures are placed on health systems.[16,17,22,25]

To properly address and define the risk disasters pose to people with NCDs, public health focus of disaster management should be expanded to include the management of people with NCDs. To better identify the much needed administrative and operational platform for this to occur, a systematic review of the literature identifying and describing the impact of cyclone, flood and storm related disasters on people with the four major NCDs was completed. The NCDs included: cardiovascular diseases (heart attacks and stroke), cancers, chronic respiratory diseases (chronic obstructed pulmonary disease and asthma) and diabetes.[15,17,18]

A focus on cyclone, flood and storms is required to ensure the research reflects the natural disasters that are the most frequent and deadly across the world.[4,5] The objectives of this research were to: determine and describe the impact on the treatment management, exacerbation of and direct care for those with NCDs; and identify the impact on the health of the at-risk population with chronic NCDs. The findings presented will help public health disaster planners and professionals understand the impact of disasters on this most vulnerable population and the impact on both direct and indirect health consequences.

Methodology

An integrative review methodology was selected to systematically review literature due to its effectiveness in defining new concepts and direct applicability to practice and policy.[26,27] This methodology also allows specific aspects of previous research to be critically and methodically evaluated.[28] The PRISMA checklist was used to guide presentation of the research (Appendix 1).[29]

Consistent with an integrative review methodology the research was conducted over the stages of problem identification; literature search; data evaluation; and data analysis.[26] The problem identification phase was incorporated into the introduction section of this paper. An overview of the remaining three stages is provided in the following.

1. Literature search

The literature search included three components. The first was determining the search terms, second searching databases and third applying the inclusion/exclusion criteria. This process is described in the following.

1.1 Search terms

The search terms were determined through a process of testing, refining and finalising in Medline between November and December 2014. The Medline database was selected because it is an essential tool for biomedical and allied health researchers and practitioners conducting literature searches.[30,31] The search terms selected were: 'cyclone', 'storm' or 'flood'; and 'disaster'; and variations for 'non-communicable disease', 'cancer', 'cardiovascular disease', 'chronic respiratory disease' or 'diabetes'. The variations included were based on World Health Organization (WHO) NCD terms and include:

- Non-communicable disease: 'NCD' or 'chronic disease'.
- Cancer: 'malignant tumours' or 'neoplasms'.[32]
- Cardiovascular disease: 'coronary heart disease', 'cerebrovascular disease', 'peripheral arterial disease', 'rheumatic heart disease', 'congenital heart disease', 'deep vein thrombosis' or 'pulmonary embolism'.[33]
- Chronic respiratory diseases: 'asthma', 'chronic obstructive pulmonary disease', 'COPD', 'occupational lung diseases', 'lung disease' or 'pulmonary hypertension'.[34]
- Diabetes: no variations, this term is specific for a condition where the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produce.[35]

To further maximize the search variations of NCD terms those identified by WHO were used and included: 'COPD' and 'respiratory disease' for chronic obstructive pulmonary disease; 'lung disease' for occupational lung diseases; and 'heart disease' for coronary, rheumatic and congenital heart disease. Other terms such as obesity, chronic pain and alcohol related disorders were considered, however, they were not identified as NCDs by WHO. Based on this, the final search terms used were:

(Cyclone OR storm OR flood) AND ((non-communicable disease OR NCD OR chronic disease) OR (cancer OR malignant tumours OR neoplasms) OR (cardiovascular disease OR coronary heart disease OR cerebrovascular disease OR peripheral arterial disease OR rheumatic heart disease OR congenital heart disease OR deep vein thrombosis OR pulmonary embolism) OR (chronic respiratory diseases OR asthma OR chronic obstructive pulmonary disease OR COPD OR occupational lung diseases OR lung disease OR pulmonary hypertension) OR (Diabetes) AND (disaster).

1.2 Databases

A search of CINAHL, Medline, PsycINFO, Science Direct and Scopus databases was conducted in January 2015 with a date limit of 31 December 2014. These databases were selected to maximise the literature searched and minimise the risk of missing relevant articles. To further maximise the scope of the literature

examined, reference lists of obtained literature were reviewed. Google Scholar was considered as one of the databases, however, the publications are not listed in relation to quality, they are displayed in relation to visits.[36] Also, the retrieval and record management mechanisms lack quality when compared to other databases.[37,38] For these reasons, Google Scholar was only used to explore reference lists and citations of obtained literature.

The search strategies differed based on the database functionality (Table 1). The Medline search was limited to articles with abstracts and references, pharmacological actions, humans and core clinical journals; Science Direct to health, patient, public health, disaster, emergency and medical; and Scopus to nursing, health professions, pharmacology, toxicology and pharmaceutics. No limitations were applied to CINAHL and PsycINFO. This approach combined with the searches of reference lists and citations in Google Scholar was designed to increase accuracy and ensure the search was tailored to each database.

Table 1. Search strategy: terms, databases, limitations and number of articles for review

Search terms	Database	Limitations	Articles for review
(Cyclone OR storm OR flood) AND ((non-communicable disease OR NCD OR chronic disease) OR (cancer OR malignant tumours OR neoplasms) OR (cardiovascular disease OR coronary heart disease OR cerebrovascular disease OR peripheral arterial disease OR rheumatic heart disease OR congenital heart disease OR deep vein thrombosis OR pulmonary embolism) OR (chronic respiratory diseases OR asthma OR chronic obstructive pulmonary disease OR COPD OR occupational lung diseases OR lung disease OR pulmonary hypertension) OR (Diabetes)) AND (disaster)	CINAHL	Nil	11
	Medline	Articles with abstracts, articles with references, pharmacological actions, humans and core clinical journals	315
	PhysicalNFO	Nil	14
	Science Direct	Health, patient, public health, disaster, emergency, medical	467
	Scopus	Medicine, nursing, health professions, pharmacology, toxicology and pharmaceutics	1,581

1.3 Inclusion/exclusion criteria

An article was considered valid if the inclusion criteria was achieved, this included: discussing how cyclone, flood or storm related disasters impacted people with NCDs. Papers were selected from peer-reviewed journal articles which were either descriptive (described a situation or a specific disaster), mixed methods, qualitative or quantitative in their methodology. Papers were excluded if they did not focus on NCDs and discussed cyclone, flood or storm related disasters. Conference abstracts and literature reviews were also excluded. The primary data sources from literature reviews were reviewed.

2. Data evaluation

The evaluation was conducted following the principles of qualitative research and included organizing the data, reading and memoing and data description.[39,40,41] The method for each is:

- Data organisation: After being sourced the data (papers) were saved electronically and, where appropriate, hard copies stored on file.[39]
- Reading and memoing: The process was conducted through a combination of electronic notes and by hand using a highlighter and pen.[39,40,41] The information gathered was captured electronically (a table embedded in a Microsoft Word ™ Document) and coded according to key phrases, ideas and concepts.[39,40,41]
- Data description: an individual description was developed for each paper. This included categorizing the papers into four data types: descriptive; mixed methods; qualitative; quantitative or mixed methods. This was followed by describing each paper's key phrases, ideas, concepts and grouping papers by each NCD.[39]

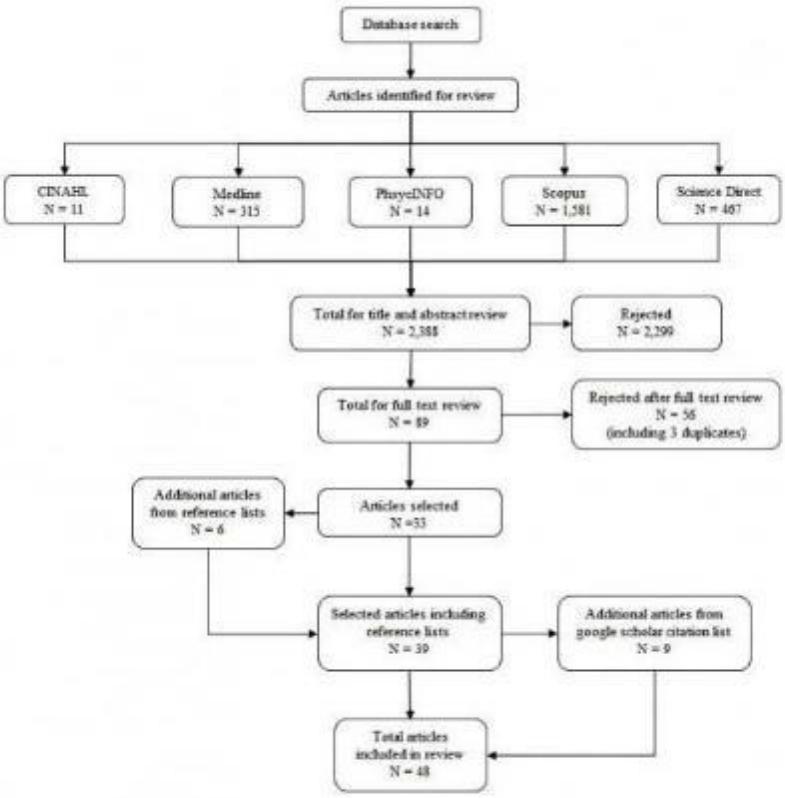
3. Data analysis

The data was analysed through an aggregation of individual papers to create an overall data description. The descriptions of NCDs were placed in a matrix to provide an overview of the issues identified. This included columns on the impact on treatment management and care; and the health impacts of cyclone, flood and storm related disasters. This process allowed the impacts and risks to the health and well-being of people with NCDs to be systematically identified and described.

Results

The search strategy identified 48 relevant articles. Initially 2,388 potentially relevant articles were identified. After a title and abstract review, 2,299 articles were rejected based on exclusion criteria and 89 selected for full text review. After the full text review 56 articles were rejected (including three duplicates), 33 selected for analysis and an additional six identified from the reference lists. The Google Scholar citation list for the 39 relevant articles identified an additional nine articles (Figure 1).

Figure 1. Literature Flow



The most common data type was a quantitative article (n=24; 50%) followed by descriptive (n=21; 44%), mixed methods (n=2; 4%) and qualitative (n=1; 2%) (Appendix 2). Based on this, it can be estimated that 54% (n=27) of articles were not descriptive.

Of the 48 articles, 23 (49%) focused specifically on hurricanes, three on tsunamis (7%), two on floods (4%), two on blizzards, snowstorms or ice storms (4%) and one each (1%) for cyclone and mudslide from a rain event. The remaining 16 (33%) focused on more than one disaster type. Of the articles that focused on more than one disaster type: ten included floods, ten hurricanes, three tsunamis, three storms, two cyclones, one typhoon, one windstorm and one tornado. Other disaster types identified, which were not part of this research, were earthquake (n=7), volcano (n=2) and fire (n=1).

The most common disaster discussed was Hurricane Katrina (n=17) followed by the 2011 Japanese Tsunami (n=3) and Hurricane Iniki (n=2). Other disasters discussed (n=1) were the New York Snowstorm (1987), Maine Ice Storm (1998), mudslide due to heavy flooding in Japan in Kagoshimi Prefecture (2012), flooding in Thailand (2010) and Hurricane's Andrew (1992), Marilyn (1995) and Sandy (2012). The remaining articles focused on the general impact of cyclone, flood and storm related disasters. The United States of America (USA) was the origin for the majority of articles (n=36, 74%), followed by Japan (n=5, 10%) and the United Kingdom (n=2, 4%). Other locations (n=1) were Australia, Denmark, Puerto Rico, South Korea and Thailand.

There were 24 different descriptions of NCDs in this research. An additional 21 conditions were also described by the 48 articles reviewed. This provided a total of 45 descriptions for NCDs (Table 2). For the NCDs targeted by this research, cardiovascular had the largest number of total descriptions (n=11) followed by chronic respiratory disease (n=8), diabetes (n=4) and cancer (n=1). All descriptions of cancer included the word cancer. The additional 15 descriptions were grouped into mental health (n=10), renal diseases (n=6) and other (n=5). The other conditions were arthritis, cystic fibrosis, HIV/AIDS, sickle cell disease and visual impairment. As mental health, renal diseases and other descriptions identified were not a focus of this research they were excluded from the analysis. This result is further explored in the discussion.

Table 2. Non-communicable disease (NCD) categories by sub classifications

NCD category	Sub-classifications
Cancer	Cancer (n=1)
Cardiovascular	Blood pressure; cardiovascular disease; cerebrovascular diseases; coronary artery disease; heart disease; high cholesterol; hypercholesterolemia; hyperlipidemia; hypertension; myocardial infarction; stroke symptoms (n=11)
Chronic respiratory disease	Allergies; asthma; chronic lower respiratory disease; chronic lung disease; chronic obstructive pulmonary disease (COPD); pulmonary disease; respiratory conditions; respiratory illness (n=8)
Diabetes	Diabetes; diabetes mellitus; endocrine; hyperglycaemia (n=4)
Renal diseases	Kidney disease; end stage renal disease; kidney failure; liver failure; renal failure; rhinosinusitis (n=6)
Mental health	Anxiety; attention deficit hyperactivity disorder; autism; behaviour problems; depression; mental disorders; mental health; mental retardation; neuropsychotropic; psychiatric illness; seizure disorder (n=10)
Other	Arthritis; cystic fibrosis; HIV/AIDS; sickle cell disease; visual impairment (n=5)

Data Analysis – Impact, treatment management and care

The data was analyzed according to the impact of a disaster on specific and non-specific NCDs; treatment, care and services; and the health impact (for example, exacerbation of existing NCD). The category of non-specific NCDs was used because there were a number of articles that described the impact of disasters on more than one NCD. The analysis is provided in Table 3 and described in the following.

Table 3. Disaster impact on treatment management and care for people with non-communicable diseases

NCD	Impact on treatment management and care	Health impact for people with NCDs
Cancer	• Reduced access to transport, clinics, specialists, medications and hospitals.[41, 46]	• 19% increase in cancer related deaths in the 12 months following Hurricane Iniki (1992).[48, 50] • After the four hurricanes impacting Florida in 2004, cancer related deaths accounted for 19% of excess deaths: Charlie 16%, elevated for 24 days; Frances/Jeanne 17%, elevated for 16/20 days, and Ivan 32%, elevated for 37 days.[41] • After Hurricane Katrina (2005), there was anecdotal evidence of an increased incidence of patients presenting with advanced head and neck cancers.[50]
Cardiovascular disease	• Reduced access to medication and medical care.[48, 50, 42] • Delayed access to supplies.[51] • Increased medical noncompliance.[51]	• Severe exacerbations and complications such as higher blood pressure, heart attack or even death.[42, 48-50, 51, 61] • After Hurricane Iniki (1992) the number of cardiac visits increased by 173%.[48] • In the ten days after the Maine Ice storm (1998), cardiac complaints increased by 0.5%.[51] • Three-fold increase in myocardial infarction (MI) incidents two, three and six years after Hurricane Katrina (2005).[5, 46] • In the 30 days post Hurricane Sandy (2012), MI incidence increased by 22% and mortality by 31%.[50] • The incidence of cardiac presentations after mud slides in southwest Japan (2012) increased by 373% compared to the month prior.[50] • After four hurricanes impacting Florida in 2004, cardiac related deaths accounted for 34% of excess deaths.[41]
Chronic respiratory diseases	• Disruption to care, treatment, medication and health systems.[47, 52, 49, 45, 47, 49] • Loss of power for equipment such as nebulizers and oxygen.[8, 50, 51] • Increase in mold growth.[52]	• 40% of children self-reported asthma had worsened in the three months after Hurricane Katrina (2005).[50] • 3% of children began using asthma medication or inhalers in the three months after Hurricane Katrina (2005).[50] • Shortness of breath was a key symptom experienced by the Katrina-displaced population in 2005, with 13% of people reporting a pre-existing lung disease.[50] • In the two weeks after Hurricane Iniki (1992), physician visits for asthma increased by 187%.[52] • Asthma admissions were three times higher in the two weeks after Hurricane Iniki (1992).[52] • 24% of children evacuated for Hurricane Katrina (2005) ran out of asthma medications or were afraid of running out of asthma medications.[52]
Diabetes	• Disruption to glucose monitoring, medical check-ups, medication, treatment, care, activity patterns and nutrition.[1, 45, 50, 51, 53-75] • Loss of power impacting on insulin storage.[50]	• Without appropriate care following a disaster, people with diabetes may experience severe exacerbations such as diabetic ketoacidosis or even death.[45, 52] • After Hurricanes in Puerto Rico (1928 and 1932) there was a 6.8% increase in diabetes incidence.[1, 50] • In the 12 months after flooding in Hull (2007), England, glycaemic control deteriorated. This was worse for people reliant on insulin treatment compared to lifestyle and oral treatments.[46] • In the 12 months after Hurricane Iniki (1992) in Kauai, Hawaii, diabetes-related deaths increased by 161%.[45, 51, 67] • After the four hurricanes impacting Florida in 2004, diabetes related deaths accounted for 5% of excess deaths.[41, 50]
NCD-non specific	• Limited access to treatment, care, specialists, medications, health system, information, communication and transport.[1, 50, 70, 80-88] • Lack of food, clean water.[1, 50, 88] • Forgetting prescription medication when being evacuated to shelters.[1, 50]	• After a disaster there is a worsening of underlying cardiovascular and respiratory diseases, and instability of diabetes, renal diseases, asthma and COPD.[5, 50, 51, 50, 73, 84, 89] • After Katrina (2005), NCDs were the overwhelming sources of immediate demands at evacuation centres, mobile clinics and Federation Emergency Management Agency (FEMA) trailer parks.[50, 51, 89] • In the two months after Hurricane Katrina (2005) people with NCDs were more likely to present at a clinic than those without (43.5 vs 16.2%).[87] • After Hurricane Katrina (2005), 33.4% of evacuees exhibited signs of acute exacerbation of a chronic illness when arriving at a shelter.[89] • 68% of medications dispensed to Hurricane Katrina (2005) evacuees were for treatment of NCDs.[85] • 42% of presentations one month after Cyclone Nargis (2008) were for chronic conditions, many of which were poorly controlled.[90] • In Mississippi trailer parks three years after Hurricane Katrina (2005), 58% adults perceived worsening of chronic condition, and this was 68% for children.[87]

Cancer

For people with cancer, a disaster can reduce access to transport, clinics, specialists, medications and hospitals.[42,43] This often results in a reduction in access to cancer treatment management and care, which based on experiences from Hurricane Katrina can last for up to one year.[44] However, no evidence was found that a person with cancer was at risk of their illness exacerbating after a disaster. Ultimately the consequence for people with cancer is an increased risk of premature death.[45,46]

Cardiovascular Disease

Without appropriate care following a disaster, people with cardiovascular disease are at risk of severe exacerbation or complications of their illness such as high blood-pressure, heart attack or even death.[47,48,49,50,51,52,53,54,55,56,57,58,59] This risk can continue for weeks or in the case of Hurricane Katrina years.[48,52,53,54,55,60] This is generally due to limited access to medication, care and supplies; medical noncompliance; and the physical workload associated with clean-up and reconstruction.[1,49,50,57,58,59,61,62] These factors culminate in people with cardiovascular diseases being at an increased risk after a disaster of severe exacerbation of their illness which can result in premature/preventable death.[46,60]

Chronic Respiratory Disease

There is an increased risk of people with chronic respiratory diseases having acute exacerbations after a disaster.[46,47,60,63,64,65] There is often an increase in physician visits and hospital admissions related to chronic respiratory diseases after a disaster.[52,66] These exacerbations are due to a disruption in care, treatment, medication, supplies, equipment, loss of power (particularly for oxygen and nebulizer dependent patients) and overcrowding in shelters.[47,59,64,65,67,68,69] The high levels of mold and other allergens after a disaster are other factors increasing the risk of acute exacerbation.[70] The review confirmed that people with chronic respiratory diseases are at an increased risk of death after a disaster.

Diabetes

Without appropriate care following a disaster, people with diabetes are at risk of severe exacerbations or even death all of which are preventable.[1,45,50,59,71,72,73] This risk can continue for months following the event.[71] This is due to disrupted treatment, poor nutrition, loss of power for insulin storage, limited physical activity, damaged medication, lost prescriptions and disrupted activity patterns.[43,45,68,71,72,74,75,76] The greatest risk is found in people reliant on insulin.[43,71]

NCD-non specific

Disasters can cause an exacerbation of NCDs or even death due to the limited access to treatment, care, medications and transport; lack of food and clean water; and increased exposure to extremes of cold or heat.[1,76,77,78,79,80,81,82,83] Another risk factor is that people with NCDs are often evacuated without sufficient supplies of medication and pharmaceutical scripts/re-fills.[1,74,84,85,86] It is common for evacuated people to no longer have access to the care they require.[78] From a patient perspective, these factors often result in a perceived worsening of their condition, which can have negative impacts on their actual illness.[87] For people with NCDs, a lack of treatment management and care for even a short period can result in severe exacerbations and preventable death.[1,51,87,88,89]

Discussion

Cyclone, flood and cyclone related disasters interrupt treatment management and care for people with NCDs. This results in an increased risk of disease exacerbation or even death due to a range of factors, including damaged transport routes, unsafe water, reduced health services, loss of power and

evacuations.[1,9,42,46,47,49,50,52,59,62,64,65,67,69,70,76,77,78,80,81,82,83,86] A lack of appropriate care for even a short period of time puts the health and well-being of people with NCDs at risk.[50,91] This is because people with NCDs are more vulnerable than others to the stresses and disruptions of a disaster.[81]

The impact of an interruption to treatment management and care varies according to the NCD. For people with cancer there is an increased risk of death, however, no evidence of a worsening in conditions.[45,46]Cardiovascular incidents increase with exacerbations and complications such as higher blood pressure, heart attack and increased death rates.[46,48,49,50,51,52,53,54,55,56,60] Chronic respiratory diseases are associated with acute exacerbation but no increase in death rates.[9,52,59,66] People with diabetes experienced severe exacerbations, such as diabetic ketoacidosis, and an increased death rate with the risk greatest for insulin dependent diabetics.[1,45,48,50,51,71,72,73]

The reason for the variation in impact by NCD is due to the type of disruption to treatment management and care. For people with cancer, the increase in deaths can be associated with reduced access to transport, clinics, specialists, medications and hospitals.[42,43,44] The situation for people with cardiovascular diseases is similar, however, delayed access to medical care and increased medication noncompliance are associated with exacerbations or even death.[49,50,59,61,62] An exacerbation of a chronic respiratory disease is due to similar factors with a loss of power for equipment, such as nebulizers and oxygen, and mould growth additional issues.[52,59,64,66,67,69,70] For people with diabetes an interruption to glucose monitoring, activity patterns and a loss of power for insulin storage increases the risk of exacerbation or even death.[43,45,59,71,72,74,75,76]

The long term health complications for people with NCDs requires further investigation. For example, uncontrolled diabetes for extended periods can result in heart disease (heart attacks and strokes), blindness, kidney failure and lower-extremity amputations.[92,93,94,95] However, for diabetics and people with other NCDs there is limited data on the long term health complications associated with a disruption to treatment management and care due to a disaster. Understanding this, including the impact of reduced treatment efficacy, will provide a new paradigm for mitigating the impact of disasters on people with NCDs.

A challenge faced by this research and future studies is the range of descriptions for NCDs. NCDs are difficult to define because this group includes some diseases partly caused by infectious organisms (for example, cancers of the liver, stomach, and cervix) and usually excludes mental illnesses.[96] When researching NCDs all variations (forms of the disease) should be considered, for example, chronic respiratory disease can include COPD and asthma. Of the NCDs subject to this research, cancer was the only condition where a single term can be used. It is recommended that future research focused on NCDs, as a collective, is guided by the major NCDs identified by WHO (cancer, cardiovascular, chronic respiratory and diabetes).

The review and subsequent analysis was limited to articles that predominately originated from high-income countries. Although this could be considered a limitation in the transferability of the findings, NCDs now disproportionately affect low and middle income countries.[97,98] In African nations NCDs are rising rapidly and are projected to exceed communicable, maternal, perinatal, and nutritional diseases as the most common causes of death by 2030.[99] However, caution should still be taken in applying the results to low and middle income countries as NCD priorities may change.

To mitigate the risk disasters pose to people with NCDs, a multi-sectoral approach is required. NCD treatment and care is reliant on more than just health services.[100] For example, damage to transport routes prevents access to specialists, medications, nutritious food and health facilities and a loss of power is a threat for people reliant on electricity for insulin and oxygen.[42,44,52,85,87,89,7681,82,101] This interdependency highlights the need to mainstream health in disaster risk reduction activities at local, national and international levels.[101]

This research provides the platform required for expanding traditional disaster approaches by public health to incorporate NCDs. The reality of this need has been acknowledged in the Sendai Framework in the statement

(30(k)) that chronic diseases (NCDs) need to be included in the design of disaster policies and plans.[3] Specific measures may include cross-cutting disaster strategies such as multi-sectoral approaches to protect essential equipment/infrastructure, mapping health vulnerabilities within a community and stockpiling essential medicines.[102,103] The aim is to ensure people with NCDs have access to life-saving services during and after disasters.[3]

To build on this research, the next step is to understand all the factors that influence both direct and indirect (preventable) morbidity and mortality related to NCDs during and after disasters. This includes quantifying acute complications, long-term complications and disease progression (including long term health complications and impacts of reduced treatment efficacy). Once achieved, disaster planners and public health professionals will be in a position to develop and implement effective and evidence-based mitigation strategies.

Limitations

The research was influenced by the lead author's studies and work in public health and disaster management in Australia at local, state and national levels and across the Asia-Pacific. To address this, an integrative methodology was selected to systematically identify and describe the literature. This included searching multiple databases and excluding grey and non-peer-reviewed literature. Papers were only selected if they were peer-reviewed and discussed cyclone, flood or storm related disasters and the impact on people with NCDs.

A limitation of this research is the narrow focus on the NCDs investigated: cancer; cardiovascular diseases; chronic respiratory diseases; and diabetes. This approach was selected to ensure consistency with the four major disease groupings for NCDs by the World Health Organization. However, other NCDs may be impacted more significantly by a disaster. For this reason caution should be taken in applying the results to other NCDs.

Conclusion

Cyclone, flood and storm related disasters impact on treatment management and overall care for people with NCDs. This results in an increased risk of exacerbation of illness or even death. The interruption may be caused by a range of factors, such as damaged transport routes, reduced health services, loss of power and evacuations. The health impact varies according to the NCD. For people with chronic respiratory diseases, a disaster increases the risk of acute exacerbation. Meanwhile, for people with cancer, cardiovascular diseases and diabetes there is an increased risk of their illness exacerbating, which can result in death. To address this problem, there is a need to expand traditional disaster approaches by public health to incorporate NCDs. The reality of this need is further highlighted by the statements in the Sendai Framework. Specific measures may in include a multi-sectoral approach to ensure people with NCDs have access to life-saving services during and after disasters. To achieve this, the next step is to understand all the factors that influence both direct and indirect (preventable) morbidity and mortality related to NCDs during and after disasters. Once achieved, disaster planners and public health professionals will be in a position to develop and implement effective and evidence-based mitigation strategies.

Human Participation Protection

Study protocol approval was not needed as there was no direct human participation in the study.

Competing Interests

The authors have declared that no competing interests exist.

Appendices

Appendix 1. PRISMA Checklist

Appendix 2. Individual Case Description

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Appendix D: Publication 4 – The role of environmental health in understanding and mitigating post-disaster noncommunicable diseases: The critical need for improved multidisciplinary solutions

INTERNATIONAL PERSPECTIVES/SPECIAL REPORT

The Role of Environmental Health in Understanding and Mitigating Postdisaster Noncommunicable Diseases: The Critical Need for Improved Interdisciplinary Solutions

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Abstract Improvements in life expectancy and changes in lifestyle have contributed to a "disease transition" from communicable to noncommunicable diseases (NCDs). Damage to public health infrastructure (PHI), such as sanitation and water, places people with NCDs at risk of disease exacerbation or even death. We propose the interdisciplinary characteristics of environmental health (EH) and the indirect, but vital, role in maximizing treatment and care for people with NCDs demonstrates the profession is an essential resource for addressing this problem. To explore this proposal, five focus groups were conducted with 55 EH professionals in Queensland, Australia. Relationships were identified between NCD exacerbation and PHI, such as power, sanitation, services, supplies, and water. Preparedness and response activities should focus on this priority PHI, which will require EH professionals to be part of interdisciplinary solutions. Recognizing this role will help protect the health of people with NCDs during and after a disaster.

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Appendix E: Publication 5 – Reducing disaster exacerbated non-communicable diseases through public health infrastructure resilience: perspectives of Australian disaster service providers

PLOS | CURRENTS DISASTERS

Reducing disaster exacerbated non-communicable diseases through public health infrastructure resilience: perspectives of Australian disaster service providers

July 13, 2016

Citation

Ryan B, Franklin RC, Burkle Jr. FM, Smith E, Watt K, Leggat P. Reducing disaster exacerbated non-communicable diseases through public health infrastructure resilience: perspectives of Australian disaster service providers. PLOS Currents Disasters. 2016 Jul 13. Edition 1.

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Abstract

Background: The exposure of people and infrastructure to flood and storm related disasters across the world is increasing faster than vulnerability is decreasing. For people with non-communicable diseases this presents a significant risk as traditionally the focus of disaster management systems has been on immediate trauma and communicable diseases. This focus must now be expanded to include the management of non-communicable diseases because these conditions are generating the bulk of ill health, disability and premature death around the globe. When public health infrastructure is destroyed or damaged access to treatment and care is severely jeopardized, resulting in an increased risk of non-communicable disease exacerbation or even death. This research proposes disaster responders, coordinators and

government officials are vital assets to mitigate and eventually prevent these problems from being exacerbated during a disaster. This is due to their role in supporting the public health infrastructure required to maximize treatment and care for people with non-communicable diseases. By focusing on the disaster cycle as a template, and on mitigation and prevention phases in particular, these actions and activities performed by disaster service responders will lead to overall improved preparedness, response, recovery and rehabilitation phases.

Methods: Data was collected via 32 interviews and one focus group (eight participants) between March 2014 and August 2015 (total of 40 participants). The research was conducted in the State of Queensland, Australia, with disaster service providers. The analysis included the phases of: organizing data; data description; data classification; and interpretation.

Results: The research found a relationship between the impact of a disaster on public health infrastructure and increased health risks for people with non-communicable diseases. Mitigation strategies were described for all phases of the disaster cycle impacting public health infrastructure. Specific measures include: increasing the use of telemedicine; preplanning with medical suppliers; effective town planning; health professionals visiting evacuation centers; evacuation centers having power for medical equipment; hubs for treatment and care after a disaster; evacuation of high risk people prior to disaster; mapping people at risk by non-communicable disease; and a mechanism for sharing information between agencies. A common theme from the participants was that having accurate and easily accessible data on people with non-communicable diseases would allow disaster service providers to adequately prepare for and respond to a disaster.

Conclusion: Disaster service providers can play a vital role in reducing the risk of disaster exacerbated non-communicable diseases through public health infrastructure resilience. They are often employed in communities where disasters occur and are therefore best-placed to lead implementation of the mitigation strategies identified in this research. To sustainably implement the mitigation strategies they will need to become integrated into effective performance and monitoring of the disaster response and health sector during non-disaster periods. For this to occur, the strategies should be integrated into business and strategic plans. Achieving this will help implement the Sendai Framework for Disaster Risk Reduction 2015-2030 and, most importantly, help protect the health of people with non-communicable diseases before, during and after a disaster.

Funding Statement

This research was supported by funding from the Australian Health Service Innovation and Cunningham Centre / Toowoomba Hospital Foundation, Australia. In kind support was provided by James Cook University, Australia, Cairns and Hinterland Hospital and Health Service, Queensland, Australia.

Introduction

Extreme weather-related disasters are becoming increasingly frequent, due largely to a sustained rise in intensity, severity and frequency of floods and storms (including cyclones, hurricanes, typhoons and tornadoes).[1234567] For example, flooding accounted for 47% of all weather-related disasters from 1995 to 2015, affecting 2.3 billion people, with storms (less frequent) having the highest mortality.[1] During this period the exposure of the population and infrastructure to weather-related disasters across the world also increased.[28]

The bulk of ill health, disability and premature death around the globe now generates from non-communicable diseases (NCD).[910] A combination of population aging, increasing obesity, decreasing physical activity, environmental change and a reduction in communicable diseases has contributed to this epidemiological transition to NCDs.[5911121314151] However, the traditional focus of the disaster response has been on the management of immediate trauma and communicable diseases.[5] This focus remains despite

the actual risk of post-disaster communicable disease outbreaks being low, particularly in developed countries.[6151617] This highlights the need to refocus disaster risk reduction strategies and resources to the most vulnerable populations.[23458718]

The high-burden of NCDs presents a challenge for disaster and health systems, especially when public health infrastructure (PHI) is destroyed, inaccessible or damaged. In this situation treatment and care is often jeopardized, which can result in disease exacerbation or even death.[581415192021222324] People with NCDs at greatest risk are those with underlying cardiovascular and respiratory diseases, undergoing cancer treatment, unstable diabetes and renal diseases.[614202526272829] PHI priorities in the disaster setting include: workforce; water; sanitation; equipment; communication; physical structure; power; governance; prevention; supplies; service; transport; and surveillance.[30] All mentioned are vital for maximizing treatment and care for people with NCDs and must be properly maintained.[113132]

The challenge of NCDs has been recognized in the *Sendai Framework for Disaster Risk Reduction: 2015-2030* (Sendai Framework), which is complementary to and builds on the *World Health Organization Global Action Plan for the Prevention and Control of Noncommunicable Diseases – 2013-2020*.[10] NCDs should be part of policy design and implementation of plans to manage risks before, during and after disasters, including having access to life-saving services.[933]

Despite this recognized challenge, research on the strategies required to implement the Sendai Framework are scarce. This is a significant risk, particularly in the state of Queensland, Australia, where NCDs cause approximately 90% of all deaths, account for 88% of the burden of disease and are responsible for 83% of recurrent health expenditure (these trends are similar across Australia).[3435] The burden of NCDs, although lower at 78%, is also a major concern for Indigenous people with these conditions being responsible for 80% of the mortality gap (69.1 years for males, 10.6 years lower than non-Indigenous; 73.7 years for females, 9.5 years lower than non-Indigenous).[3637] The burden of NCDs is at its worst in rural and remote areas because as the distance from major cities and regional centers increases, the disease risk factors increase.[38]

This paper is part of a project aiming to develop strategies for reducing disaster exacerbated NCDs through PHI resilience.[561530] Specifically this study focuses on the perspective of responders, coordinators and government officials designated as disaster service providers. In the wider project different approaches have been used to gather information around NCDs and PHI resilience. Participant groupings include: environmental health professionals (via focus groups)[15]; disaster service providers (via interviews and a focus group – this paper); and people with NCDs (via interviews). Combing these groups into one research paper would have prevented the individual challenges, nuances and recommendations for each group from being truly understood. Each group has a unique, discrete and important perspective, for example, the environmental health profession addresses risks relating to drinking water, sanitation, food safety and mass gatherings.[3239] Disaster service providers are responsible for overall leadership, designing and managing system-wide preparation, prevention, response and recovery phases of disaster management.[40] Meanwhile, people with NCDs represent the group at greatest risk of disease exacerbation if impacted by a disaster.[8]

The aim of this research was to explore the role of disaster service providers in reducing disaster exacerbated NCDs through PHI resilience. To achieve this, interviews and a focus group were conducted with disaster service providers in the State of Queensland, Australia. This included investigating descriptions of PHI from their perspective, the impact of disasters on PHI and proposed resilience strategies, disaster impact by PHI and NCD, and identification of mitigation strategies by PHI.

Methods

Data was collected via 32 interviews and one focus group (eight participants) between March 2014 and August 2015 with 40 disaster service providers representing ten organizations. The qualitative analysis

included the phases of: organizing data; data description; and data classification and interpretation.[41,42,43] A description of the research area, definitions and the analysis process are provided in the following.

Research area

The research areas included: Cairns and Hinterland Hospital and Health Service (HHS); Darling Downs HHS; and Townsville HHS. All are located in the State of Queensland, Australia. Government officials with disaster management responsibilities in Brisbane (State Capital) were also included as their decisions directly influence PHI, management of NCDs and disaster responses.

The focus on Cairns and Hinterland HHS, Darling Downs HHS and Townsville HHSs was due to their NCD burden and recent disasters.[44,45] For example, Cyclone Larry (2006), flash flooding in the Lockyer Valley (2011); and Cyclone Yasi (2011), which resulted in widespread damage to PHI.[16] Natural disasters are a feature of the climate and landscape in these regions and are anticipated to increase, with climate change expected to make extreme weather events such as floods and storms more frequent.[16,46,47]

The Cairns and Hinterland HHS services a population of just over 280,000. Of this population, 9% are Indigenous, compared to 3.5% for Queensland and 2.5% for Australia.[48,49] The Darling Downs HHS services a population just under 280,000 and Indigenous people make up 4.2 per cent of the population.[50] The Townsville HHS services a population of approximately 240,000 and 7% are Indigenous.[51] There are no demographics for Brisbane because this is primarily the location of government officials who influence PHI, management of NCDs and disaster responses from a state-wide perspective.

Definitions

Disaster service providers

The experiences of three types of disaster service providers were explored: responders, coordinators and government officials. Disaster service providers were invited to participate because their perceptions, experience and knowledge is vital in influencing strategies for reducing disaster exacerbated NCDs through PHI resilience. A description of each group is provided below:

- Responder: This group includes doctors, nurses, paramedics, police officers and representatives from non-government organizations such as the Australian Diabetes Educators Association, Australian Red Cross and the Kidney Support Network. Discussions with this group addressed the preparedness, prevention, response and recovery arrangements and the role of various individuals, organizations and leading local players in disaster health management.[40]
- Coordinator: This group includes local disaster coordinators, members of local and district disaster management groups and disaster management officers from Queensland Fire and Emergency Services. This group provides a conduit between Local and State Disaster Management Group's groups and has specialist knowledge of the principles of disaster management.[40]
- Government officials: This group includes representatives from the Department of Health (Queensland), Queensland Police Service, Queensland Fire and Emergency Services and Queensland Ambulance Service who had a state-wide disaster management role. This group was based in the State Capital of Queensland, Australia (Brisbane). Overall this group is responsible for leading, designing and managing the state-wide preparation, prevention, response and recovery phases of disaster management.[40]

Non-communicable disease (NCD)

The NCD terms used to guide the analysis were cancer, cardiovascular diseases, diabetes, respiratory conditions and renal diseases.[6] These conditions are at greatest risk of exacerbation after a disaster and are long-lasting and place great burden on patients, health services and fiscal systems.[45,52] A category of NCD-general was used for additional conditions identified by participants.

Public Health Infrastructure (PHI)

PHI was considered the workforce, equipment, supplies, and services required to maintain the health and well-being of individuals and the community.[30] Beyond this definition, there were 13 PHI themes used to guide the analysis and (in priority order) included: workforce; water; sanitation; equipment; communication; physical structure; power; governance; prevention; supplies; service; transport; and surveillance.[30]

Resilience

Resilience is the capacity to prevent, mitigate, prepare for, respond to, and recover from the impacts of disasters.[53,54] In this context resilience focuses on enhancing the ability of PHI to minimize the effects of future disaster events on people with NCDs. Resilience is a dynamic quality and is usually developed and strengthened over time, it builds upon rather than replaces existing strengths and arrangements.[54]

Data collection

Data was collected through interviews and focus groups, which were guided by a combination of structured and open-ended questions developed by the research team. The aim was to understand the role disaster service providers could have in maximizing the treatment and care for people with NCDs during and after a disaster. The questions focused on participant's examples of PHI; relationship between a breakdown of PHI and poor health outcomes for people with NCDs; and mitigation strategies.

The participants were recruited and selected using a purposive sampling strategy.[41] A focus group was held in Townsville and interviews conducted in Brisbane, Cairns and Innisfail (Cairns and Hinterland HHS), Townsville (Townsville HHS) and Toowoomba (Darling Downs HHS).

The principle of saturation was used to determine the number of interviews.[41,42,55,56] For convenience a focus group was held with coordinators. The point of saturation was achieved after approximately 25 interviews. The focus group and remaining six interviews did not generate any new information. The additional interviews were held to ensure all organizations and research locations had an opportunity to participate.

Data Analysis

A deductive content analysis was used to analyze the data. This included the phases of: organizing data; data description; and data classification and interpretation.[41,42,43] The process is described in the following:

1. Organizing data: the focus group and interviews were tape recorded and then transcribed. After transcription the data was saved electronically and then uploaded to QSR NVivo 10.
2. Data description: A description of the data was developed based on the key phrases, ideas and concepts. Interview participants were allocated a deidentified code, for example, *I1*, and focus group data was referred to as *FG*. Firstly, 'lean coding' was used to analyze the data. The terms were based on the descriptions of PHI and NCDs; mitigation strategies; and negative, positive and neutral impact of flood and storm related disasters on PHI and NCDs. Secondly, the codes were placed in a Microsoft Excel™ spreadsheet to develop an individual description based on the key phrases, ideas and concepts.
3. Data classification and interpretation: The data was classified through an aggregation of individual descriptions and themes in a Microsoft Excel™ spreadsheet to create an overall case description. The data was analyzed by comparing PHI descriptors with the literature, describing NCD descriptors, outlining the impact of disasters on PHI and resilience strategies, reporting the impact by PHI and NCD, and demonstrating mitigation strategies by PHI theme. The data was then interpreted in the discussion to understand the role of disaster service providers in mitigating the impact of disasters on treatment and care for people with NCDs.

Ethics

Ethics approval was provided by James Cook University (H4871), Australia, and Townsville Hospital and Health Service Human Research Ethics Committee (HREC/13/QTHS/251). Site specific ethics approval was received from the Cairns and Hinterland HHS (SSA/15/QCH/54 – Lead 147), Darling Downs HHS (SSA/14/QTDD/21) and the Townsville HHS (SSA/14/QTHS/153). This was complimented by letters to specific agencies and disaster management groups seeking permission to invite staff to participate in the research.

Results

Participants

The majority of participants were responders (40%; n=16) followed by coordinators (35%; 14) and government officials (25%; n=10) (Table 1). There were 17 female and 23 male participants. The majority of participants were from agencies in Brisbane (38%; n=15) followed by the Townsville HHS (33%; n=13), Cairns and Hinterland HHS (20%; n=8) and Darling Downs HHS (10%; n=4). Of the Brisbane based participants, n=5 were categorized as responders as they worked for non-government agencies.

Demographic		Responder	Coordinator	Government Official
Participants		16 (40%)	14 (35%)	10 (25%)
Gender		10 Female; 6 Male	4 Female; 10 Male	3 Female; 7 Male
Location	Cairns and Hinterland HHS	4	4	N/A
	Darling Downs HHS	3	1	N/A
	Townsville HHS	4	9	N/A
	Brisbane	5*	N/A	10
Disaster experience by type	Cyclone	4	4	0
	Cyclone and flood	3	4	9
	Cyclone and tornado	2	3	0
	Cyclone, flood and fire	0	2	0
	Cyclone, flood and tomado	1	0	1
	Flood	6	0	0
	Flood and fire	0	1	0
Organization type	Local Government	0	1	N/A
	State Government	9	11	10
	Federal Government	0	2	0
	Non-government Organization	7	N/A	N/A

* These participants were from non-government organizations

Table 1. Demographics

All participants had responded to a natural disaster and were in some way involved in disaster management. Most had experienced multiple disaster types with cyclone and flood the most common (40%; n=18) followed by cyclone and tornado (13%; n=5); cyclone, flood and fire (5%; n=2); cyclone, flood and tornado (5%; n=2); and flood and fire (3%; n=1). The most common single type of disaster experience was cyclone (20%; n=8) followed by a flood (15%; n=6).

The majority of participants were from State Government agencies (75%; n=30). This included 40% (n=16) from the Department of Health and HHSs followed by 22% (n=9) from the Queensland Police Service, and 10% (n=4) Queensland Ambulance Service and Queensland Fire and Emergency Service. Other participants were from non-government organizations (18%; n=7), Australian Government (5%; n=2) and Local Government (3%; n=1).

Public Health Infrastructure descriptors

The interviews and focus group identified 130 different descriptors of PHI, which were grouped into 14 themes (Table 2). In comparison, Ryan et al[30] identified 167 different descriptors for PHI, which were grouped into 13 themes. The disaster service providers identified more descriptors for prevention and water. Meanwhile, the literature identified more descriptors for all other themes. An additional theme of 'other' was identified by the participants. This was used to group pets which according to the participants should be considered a descriptor for PHI. Additional descriptors were identified by the participants for all thematical areas except power. The data is provided in Table 2.

Theme	Descriptors similar to the literature	Additional disaster service provider descriptors	Number of descriptors	
			Disaster service provider	Literature*
Communication	Communication; media (social); phone lines (telephone); public messaging (information sharing)	Advertising; public health campaigns; video conference	7	11
Equipment	Day dialysis beds (beds); equipment; medical devices; personal devices (medical devices); refrigerator; sharps (needles and syringes)	Charges; hygiene packs; microwave	9	9
Governance	Disaster management system (disaster system); hospital system; law enforcement (food safety); leadership	District disaster management group; health system; local disaster management group; non-government agencies planning; preparation; privacy; state government	12	14
Physical structure	Buildings; health service buildings (hospital infrastructure); hospital; houses; medical facilities; shelter; storage for medication (storage facilities)	Aged-care home; community health facilities; evacuation centre; sewage treatment plant; water treatment plant	12	16
Power	Electricity; generators; power; solar power	Nil	4	8
Prevention	Health promotion (promotion); prevention of disease (prevention)	Balanced diet; heat protection; hydration; removing mosquito breeding grounds; sun protection; vaccination programmes	8	4
Sanitation	Personal hygiene (hygiene); infection control; sanitation; sewage; waste management	Hygienic clinical areas; street-cleaning	7	14
Services	Ambulance (ambulance service); clinics; diagnostic care (diagnosis); emergency services (emergency medical services); healthcare services (hospital care); medical centres (medical services); nursing homes; pharmacies; vaccination (vaccine programs)	Chemotherapy; clinical follow-up; clinical waste management; community facilities; dialysis; effluent disposal; health response; immunization clinics; nursing homes; oncology services; pathology services; prescribing medicine; primary healthcare; refuse removal; sewage treatment; vector control; water treatment	26	34
Supplies	Food; gas; medication; medicine; nutritious food; prescription medication (prescription drugs); supplies	Clothing; condoms; diesel; oxygen; water supplies	12	16
Surveillance	Assessments; health data	Contact tracing; asbestos mapping; flood mapping	5	6
Transport	Bridge; roads; transport; transportation	Driveways; logistic/transport centre; road access; transit	8	9
Water	Drinking water; water supply (reticulated)	Bottled water; chlorine levels; clean water; safe water; water systems	8	4
Workforce	Doctors (general practitioners and medical personnel); environmental health professionals (officers); nurses (community nurses); public health workforce (public health personnel); staff; trained staff (health professionals)	Administrative personnel; aeronautical medical staff; people conducting assessments; technicians	11	15
Other	Nil	Pets	1	0
		Total	130	167

Table 2. Descriptions of public health infrastructure, disaster service provider perspective

Disasters impact on public health infrastructure and proposed resilience

The participants described various impacts of disasters on PHI (n=56) and proposed resilience strategies (n=37), which were categorized into two descriptors (reported impact and proposed resilience strategy). The descriptions were categorized into PHI themes outlined in Table 3 and are discussed below.

Theme	Reported impact	Proposed resilience strategies
Communication	1. Breakdown results in people losing touch with the health system. 2. Damaged systems can result in delivery of unsuitable equipment. 3. Communications can be out for ten days or longer. 4. Damaged communication can limit access to transport for treatment and care. 5. Difficult to re-engage and communicate with patients after disaster.	1. Patients encouraged to develop treatment plans post disaster. 2. Targeted communication plans, particularly for home based patients. 3. Easy access to call centre/central information service. 4. Regular communication about health service status. 5. Ongoing advertising on the need for individuals to be prepared.
Equipment	6. Dialysis equipment can become unusable due to flooding. 7. Insulin pumps, needles and syringes can become damaged and contaminated. 8. Medical equipment can be unusable due to a loss of power.	6. Patients have access to replacement medical equipment. 7. Patients have plans to maintain refrigeration of medication. 8. Refrigeration available at evacuation centres.
Governance	9. Damaged governance can impact support for the response and recovery. 10. Disaster planning is required at the individual level. 11. If there are no alternate health service plans, treatment can be jeopardised. 12. The time required for accurate weather predictions results in evacuation delays. 13. Vulnerable people often stay in-place because of limited support for evacuation.	9. Embed nurses in disaster management groups. 10. Identify people at risk and providing sufficient supplies prior to disaster. 11. Individual planning and preparation. 12. Targeted planning for people with NCDs.
Physical structure	14. Damaged housing can result in patients relocating without health service knowledge. 15. Damaged treatment infrastructure can prevent access to medical treatment.	13. Design and locate infrastructure so treatment can be maintained. 14. Evacuations centres have power for medical equipment. 15. Safe storage for medication.
Power	16. A loss of power can impact on the operation of medical equipment. 17. Drinking water can become contaminated. 18. Home phones can fail preventing people with NCDs from calling for assistance. 19. Hygiene standards can be compromised due to power outage. 20. Increased reliance on the health system by home based patients. 21. Power outage can impact food supply. 22. Refrigerator failure can impact on medication storage.	16. Back-up power sources for home based patients and health facilities. 17. Plans to ensure medicines maintained under temperature control. 18. Storage of back-up fuel for generators.
Prevention	23. A lack of individual preparation results in poor health outcomes.	19. Treatment plans for patients.
Sanitation	24. Food safety issues. 25. Increased rate of infection for dialysis patients. 26. Poor hygiene can impact on people who are immunocompromised.	20. Plans to maintain access to clean water and safe food. 21. Plans to provide a hygiene environment for immunocompromised people.
Services	27. Emergency Departments tend to be full. 28. General practitioners tend to either be full or closed. 29. If hospital services are unavailable people often go to evacuation centres. 30. Impact on treatment plans. 31. Limited access to technicians for repairing medical equipment. 32. Patients requiring health services can be cut off and unable to be evacuated. 33. Reduced access to equipment. 34. Reduced follow-up on treatment and care. 35. Visiting health services can be cut off.	22. Plans to provide health services at multiple sites. 23. Disaster management groups supporting medication management. 24. Plans to use aircraft and telehealth to provide health services.
Supplies	36. Communities resupply cut off. 37. Damage to pharmacies reducing access to medication. 38. Interruption to supply of medications. 39. Lost medications. 40. Medical supply shortages. 41. Patients often forget to bring medication to evacuation centres. 42. Patients running out of medication. 43. Reduced access to healthy food. 44. Supply sources for medication and equipment can be damaged. 45. Unable to access accessories for medical equipment.	25. Patients bring medication to evacuation centres. 26. Access to healthy foods at evacuation centres. 27. Alternative supply chains for medicines and equipment. 28. Safe water supply. 29. Refrigeration at evacuation centres for medication. 30. Storage and distribution of hygiene packs including medications.
Surveillance	46. Knowledge of people at risk.	31. Mapping of people at risk by non-communicable disease. 32. Mechanism for sharing information between agencies.
Transport	47. A loss of transport can prevent people from accessing treatment and care. 48. Limited access to taxis. 49. No transport, which can result in supplies such as medication being exhausted. 50. Patients in outlying areas can be cut off preventing access to hospitals.	33. Alternate transport options such as boats and helicopters. 34. Evacuation of high-risk people prior to disaster.
Water	51. Contamination of water can impact on hygiene standards. 52. Drinking water can become contaminated. 53. Unsafe water can compromise medical equipment such as dialysis machines.	35. Access to bottled water.
Workforce	54. Delays in support services attending sites impacted. 55. Reduced follow-up on patients. 56. The local workforce is impacted resulting in staff shortages.	36. Staff trained in disaster management systems. 37. Agency wide rapid response systems.

Table 3. Disaster impact on public health infrastructure and proposed resilience strategies, disaster service provider perspective

Impact on public health infrastructure

The participants reported flood and storm related disasters can impact all aspects of PHI. Damage to communication, equipment, power, services and supplies can result in people losing touch with the health system, limiting access to treatment and patients running out of medications. Governance, transport and workforce is often interrupted or overwhelmed, which can impact on the response and recovery, reduce access to treatment and result in some vulnerable people not being evacuated due to a reduction in support resources. Damage to physical structure, sanitation and water can prevent access to treatment, compromise medical equipment and result in poor hygiene standards, and increase the risk of infection. An interruption of surveillance reduces the knowledge-base about people at risk, making it difficult to properly target resources. Post disaster, any inadequacies in prevention activities such as poor town planning, inadequate stockpiling/storage of medications and lack of individual preparedness by with people with NCDs becomes evident. The result is interrupted treatment and care and an increased risk of poor health outcomes for people with NCDs.

Resilience strategies

The participants described resilience strategies for all phases of the disaster cycle impacting PHI. For communication, equipment, services and supplies this included encouraging targeted communication, use of telehealth, patients having their own treatment plans post disaster, providing access to back-up medical equipment and plans to provide health services at alternate sites. Governance, transport, workforce and surveillance strategies could include embedding media in disaster management groups, targeted planning for people with NCDs, use of alternate transport options, early evacuation and agency-wide staff training. Physical infrastructure and sanitation could involve designing and locating infrastructure to allow treatment to be maintained and plans to maintain a safe water supply. Resilience for power could include evacuation centers having the capability to power medical equipment and back-up power sources for home based patients and health facilities. Water supply could become resilient by ensuring access to bottled water.

Reported impact of disaster by public health infrastructure and non-communicable disease

The participants reported relationships between the impact of a disaster on PHI and increased health risks for people with NCDs. These relationships are outlined in Table 4 and discussed in the following.

Public Health Infrastructure	Cancer	Cardiovascular	Diabetes	Respiratory	Renal disease	NCD general
Communication		Lack of communication can prevent access to medication.	Lack of communication can prevent access to medication.		Phone outage can prevent home-based patients from accessing medication and services.	Communication breakdown can result in patients losing touch with healthcare system.
Equipment			Insulin pumps and syringes contaminated, lost and damaged.		Dialysis machines and equipment contaminated.	Medical equipment unusable due power loss and/or contamination.
Governance						Poor planning reduces time for assistance. If no alternate plans, treatment and care will be jeopardised.
Physical structure	If infrastructure is not resilient, people undergoing treatment may be at risk.				Renal patients require shelter, food, clothing, health and hygiene packs.	Patients often forget to bring medication to evacuation centres, infrastructure used to provide treatment can become damaged, damaged hospitals can result in patients relocating without health service knowledge, damaged pharmacies reduces access to medication.
Power			A loss of power impacts on refrigeration of insulin.	Oxygen concentrators require power, lost power results in increased reliance on ambulance service and hospitals.	Lost power impacts on dialysis machines, particularly home based.	If back-up power sources fail, treatment and care is jeopardised, increased reliance on the health system by home based patients, home phones fail preventing calls for assistance.
Prevention			Inadequate preparations by patients can result in uncontrolled diabetes.			Lack of individual preparation results in poor health outcomes.
Sanitation	Poor hygiene impacts on the health of people undergoing treatment.				Transplant patients are susceptible to poor sanitation, dialysis patients at increased risk of infection.	
Services	Interrupted access to services, reduced access to acute services as a result.	Loss of ongoing care increases risk of heart issue, reduced access to medication.	Loss of acute medical care for uncontrollable diabetes.	Reduced access acute medical care.	Interrupted access to dialysis, reduction services reduced.	Patients requiring health services cut off and unable to be evacuated, reduced follow-up, lack of acute medical care.
Supplies	Health compromised by consuming unsafe food, medical supply shortages.	Increased risk of cardiac arrest if no medication, medication forgotten when evacuated, medication supply interrupted.	Lack of medication increases risk of uncontrolled diabetes, limited access to nutritious food, low access to medical accessories and supplies.	If oxygen supplies run out patient sent up to hospital, increased reliance on ambulance service to supply oxygen to evacuate patients.	Medication supply reduced (transplant patients at greatest risk).	Patients run out of medication, interruption to medication supply, community resupply cut off.
Surveillance						Limit knowledge of people at risk and their location.
Transport	Patients specialist travelling to areas cut off, reduced access to treatment.	Damaged transport reduces medication supply.	Medication supply reduced due to being cut off, loss of access to acute medical care.		Transport interruption prevents access to hospitals, particularly for home based patients if not evacuated early, creates challenges for emergency services.	Loss of transport results in medication being unlicensed, patients cut off preventing access to treatment, supplies from other locations not provided.
Water	Health compromised by unsafe water.				Can compromise medical equipment, safe water helps ensure sanitary conditions, increased pressure on dialysis centres due to interrupted home based treatment.	Increased communicable disease risk, unsafe water compromises treatment and care, contaminated water impacts on hygiene standards.
Workforce			Adequate resources required to answer phone calls from patients.		Dialysis centres and hospitals require staff to accommodate influx of home based patients.	Limit workforce often reported resulting in staff shortages, Reduced staff results in limited follow-up on patients.
Other				People often do not leave due to fear pets, even if oxygen is running low.		

Table 4. Reported impact by public health infrastructure and non-communicable disease, disaster service provider perspective

Communication

Disrupted communication was reported to impact on people with cardiovascular, diabetes, renal diseases and more generally those with NCDs. The cardiovascular and diabetes impacts relate to a loss in communication preventing access to medication. For people with renal diseases, the risk is predominately for home based patients because damage to phone lines can make it difficult to check if the patient is dialysing. More generally, communication breakdown after a disaster can result in patients being *"...dropped out of the health system...they can't access health services...we lose them, they're very hard to re-engage...(I31)"*.

Equipment

Equipment damage or interruption can impact people with diabetes, renal diseases and more generally those with NCDs. For people with diabetes equipment can become lost or damaged. Dialysis machines and associated equipment can become contaminated. For example, *"...the machine will clog up...there's a potential risk of losing the blood in your lines, some stuff leaking through and coming into your blood system, because the machine is not working at 100%...(I3)"*. Also, medical equipment can become unusable for long-periods, particularly due to a reduction in access to technicians and other resources required for repair work.

Governance

An interruption to governance can impact on the health of people with NCDs, particularly if there is inadequate planning by agencies and individuals. For example, there are *"...plenty of examples of people with non-communicable diseases needing assistance in shortened time-frames which could have been avoided if they had...that planning and preparation...in place...(I1)"*. Another concern was that *"...people who are at home they tend to be our biggest problem within the district level and the local level... There's no lists and no collective storage of information on these particular people...(FG)"*.

Physical structure

Damage to physical structure can impact on the health of people with cancer, renal diseases and more generally NCDs. For people with cancer, curative treatment can become compromised, for example, if *"...someone is in the middle of a curative treatment...you need to be able to have infrastructures to maintain treatment...(I27)"*. Renal patients also require *"...shelter, food, clothing, health and hygiene packs...(I4)"*. More generally, the result is reduced access to treatment and care.

Power

An interruption to power can affect people with diabetes, respiratory conditions, renal diseases and more generally those with NCDs. A power outage can impact on refrigeration of insulin for people with diabetes. For people with respiratory and renal diseases there can be a reduction in access to treatment and life-sustaining equipment. Also, for people with respiratory conditions it can result in an increased reliance on the ambulance service, which can have a negative impact on the entire health system. For example, *"...they lose the power; that then impacts on them; their families, ourselves as the ambulance service, because then we've got to either try to supply some oxygen to them in the short term; take them to hospital which then impacts on the hospital's ability to respond to significant events in an emergency department... (I32)"*. A power outage can also impact on communication, preventing calls for assistance.

Prevention

Inadequate prevention activities can affect people with diabetes and more generally those with NCDs. Inadequate preparedness by patients can result in uncontrolled diabetes. For example, they *"...tend to have a lot of phone calls mainly in the form of uncontrolled blood sugar... a lot of them will tell you that they lost the paper or the medication...(I26)"*. More generally, a lack of individual preparation for a disaster results in poor health outcomes post-disaster.

Sanitation

Damage to sanitation can impact on people with cancer and renal diseases. Poor hygiene can impact the health of people undergoing cancer treatment, for example, *"...when people are on chemotherapy and if their immune system is down...need to make sure that the water quality is good..."*. Also, for people with renal diseases *"...there's lots of elements that hygiene's really essential... I think about their water quality; I think about their exchange areas. Is it clean and hygienic?...(I27)"*. The risk is greatest for transplant patients and those undergoing dialysis treatments.

Services

A lack of services can impact people with cancer, cardiovascular, diabetes, respiratory conditions, renal diseases and more generally NCDs. Interrupted access to services and medication can compromise the heath of people with cancer, cardiovascular, diabetes, respiratory conditions and renal diseases. For example, *"...we also had a visiting oncology service. We didn't actually have a medical oncologist who was located here at Toowoomba Hospital so they were cut off from us...(I7)"*. More generally, follow-up care for people with NCDs can be reduced because patients impacted by a disaster can lose access to treatment and then move without advising the health service.

Supplies

Damage to supplies can impact on people with cancer, cardiovascular, diabetes, respiratory conditions, renal diseases and more generally NCDs. For people with cancer this risk relates to unsafe food and medical supply shortages. If medication is not available, people with cardiovascular conditions are at an increased risk of a cardiac arrest, diabetes can become uncontrolled and the overall health of renal transplant patients is at risk. For people with respiratory diseases this can result in an increased reliance on the ambulance service and hospitals to maintain treatment and care. More generally people with NCDs often forget medication when evacuated. For example, *"...if it increases the stress on that person, then there's no doubt it could well have an impact if they have heart disease or cancer or any other condition... (I12)"*.

Surveillance

Disruption to surveillance can indirectly impact on people with a range of NCDs. For example, *"...there's a lot of people who do stay at home, who, in fact, may not have been impacted, like their house is okay, but they still might be isolated because of flood roads, so they're the ones we don't know anything about... (I24)"*. Another situation was described where there was *"...no database...(I27)"* to determine *"...how many...patients are home-oxygen dependent or home-dialysis dependent...(I27)"*. The result is an inability to proactively allocate the resources required to help people most at risk of disease exacerbation.

Transport

Damage to transport can impact on people with cancer, cardiovascular, respiratory, renal diseases and more generally NCDs. For example,*"...patients from all outlying areas were cut off from...services here at...Hospital...(I7)"*. Also, *"transport mechanisms to get them from home to the treatment facilities, because the majority don't have vehicles...(FG)"*. Overall, the loss of transport reduces access for people with NCDs to services, medication supply and acute medical care.

Water

Disrupted water supply can impact on people with cancer, renal diseases and more generally NCDs. Unsafe water can compromise the health of people with cancer and the medical equipment used to treat people with renal diseases. For example, *"The water systems...have a huge impact on the dialysing machines that filter the water...(I3)"* and if not filtered correctly *"...stuff in the water could get into the patient's blood...(I8)"*. Overall, for people with NCDs there can be an increased risk of infection and communicable diseases due to unsafe water reducing hygiene standards.

Workforce

An interruption to the workforce can impact on people with diabetes, renal diseases and more generally NCDs. For example, *"...our biggest thing was staffing...getting staff...(I30)"*. For people with diabetes, a reduction in the workforce can prevent access to specialist advice. For example, after a recent cyclone *"...we had lots of phone calls from patients that they've had high blood glucose levels, unwell, or distressed because they've lost their power, wanting to know how to store medications...(I20)"*. A reduction in staff at dialysis centres can compromise treatment of home based patients who need rapid access to an alternate treatment facility. More generally, a reduction in staff can reduce follow-up on patients.

Other

Respondents were aware of cases where people dependent on oxygen (respiratory assistance machines) often do not evacuate due to their pets, even if their supply is running low.

Mitigation strategies

Participants described 72 strategies for mitigating the impact of disasters on treatment and care for people with NCDs. The strategies have been categorized by PHI and participant group in Table 5.

Table 5 – Mitigation strategies by public health infrastructure and responsible area, disaster service provider perspective

Mitigation strategies were described for all phases of the disaster cycle. For communication, governance, services and the workforce this could include: use of telemedicine; providing brochures at shelters; regular communication about the health service status; close working relationship between public and private sectors; preplanning with medical suppliers; effective town planning; health professionals visiting evacuation centers; and staff trained in disaster management systems. Equipment, physical structure, power, supplies; transport and water strategies include: storage of back-up medication and equipment in secure locations; evacuation centers having power for medical equipment; hubs for treatment and care after a disaster; general practitioner surgeries having back-up power; alternate supply chains; and evacuation of high risk people prior to disaster. Prevention, sanitation and surveillance would include: emergency treatment kits for people with NCDs; people with NCDs understanding their vulnerabilities; providing a hygienic environment; mapping people at risk by NCD; and a mechanism for sharing information between agencies.

The responder group suggested the highest number of mitigation strategies followed by government officials and coordinators. Responders identified 19 unique mitigation strategies, government officials 15 and coordinators three. There were 14 mitigation strategies identified by both responders and government officials. Responders and coordinators identified five similar mitigation strategies. The coordinator and government official groups identified five similar strategies. There were 11 mitigation strategies identified by all groups.

All groups identified mitigation strategies within the PHI categories of communication, governance, prevention, sanitation, supplies, surveillance (described in next paragraph), transport and workforce. Communication related to the need for ongoing advertising on the need for individuals to be prepared and this was complimented by governance where individual planning and preparation is required. From a prevention perspective all groups recommended emergency treatment kits are provided for people with NCDs and for sanitation access to clean water and safe food needs to be maximized. Supplies relate to ensuring a surplus of equipment and medication for the disaster season. For transport multiple options, such as boats and helicopters, are required and this would support the workforce strategy of ensuring inter-agency rapid response systems were in-place.

Two surveillance strategies were recommended by all groups. These included mapping and the sharing of information about people with NCDs. For example, *"...GPs forwarding through...to the Local Disaster Management Group a list of their patients that they believe to be at risk, so that perhaps we can plan to*

manage those at-risk patients prior to the event rather than wait until after the event…(I27)". Another consideration is *"…having a map almost, or an indicator that we've got…dialysis patients and these are their addresses. And then you can then work out what you need to from there. This person can last 24 hours without dialysis or two days or two hours…(I8)"*. A common theme from the participants was that having accurate and easily accessible data on people with NCDs would allow disaster service providers to adequately prepare for and respond to a disaster.

Discussion

Disaster service providers are best placed to lead implementation of strategies for reducing the impact of disasters on people with NCDs. This is because their activities cut across the entire spectrum of the disaster system, including with government, non-government and private sectors. They are employed in communities where disasters occur and the core elements of their work are directly linked to enhancing PHI resilience. Specific measures include: increasing the use of telemedicine; preplanning with medical suppliers; effective town planning; health professionals visiting evacuation centers; evacuation centers having power for medical equipment; hubs for treatment and care after a disaster; evacuation of high risk people prior to disaster; mapping people at risk by NCD; and a mechanism for sharing information between agencies.

Within the disaster service provider group, responders are best placed to lead and guide implementation of the mitigation strategies. For example, the *"…local system needs to feed into the hierarchy of command and the patient should only be having contact with that local person…(I4)"*. This could only occur with support from coordinators and government officials. The importance of responders leading this work is further supported by the high number of mitigation strategies recommended by this group, which reflects their work 'on the ground' before, during and after disasters. Meanwhile, the coordinator group provides the much needed conduit between responders and government officials.

Disaster service providers consider themselves responsible for maximizing treatment and care for people with NCDs. For example, a situation was described where *"…we knew the bridge was going to go under, so we ensured that the people that needed medication were identified in that township and we ensured that they had their medications, because they were going to be isolated…(I9)"*. This combined with the wide range of disciplines among disaster service providers demonstrates they can provide the leadership required to systematically expand the focus of disaster systems to include NCDs. To guide implementation of this change, PHI and NCD considerations are discussed in the following along with implementation of the mitigation strategies outlined in Table 5.

Public health infrastructure considerations

A relationship was identified between damage to PHI and an increased risk of disaster exacerbated NCDs. This concern is consistent with the literature which has found that when PHI is destroyed or rendered inaccessible, access to chronic care treatment and medication is jeopardized.[1955] Also, acute care can also become compromised and this presents a risk for people with NCDs, for example, orthopedic surgery is at much higher risk when a patient has poorly controlled cardiovascular disease.[57]

An interruption to transport will not only decrease access to services but reduce the ability to provide care. To overcome this risk, strategies need to be in-place to allow the disaster service providers to provide care and treatment during and immediately after a disaster.[30] This could include disaster and health planners encouraging those who provide care to have personal disaster plans. This proposal compliments other research which has found the willingness of nursing staff to attend a workplace after a disaster increases by eight times if they have a disaster plan.[59] Also, people are more likely to attend work after a disaster if their colleagues are prepared for disaster response.[59]

Pets should be considered part of PHI. For example, people *"…won't leave because of their pets…(I10)"* even if *"…their oxygen was running really low…(I10)"*. There is also the risk that people with pets will not

attend evacuation centres and there can be difficulty in convincing farmers to evacuate when livestock is at risk.[15] For this reason, when developing plans it is important disaster and health planners consider how pets will be handled.

The identification of additional descriptors (Table 1) for the PHI themes identified by Ryan et al[30] is another step towards describing and categorizing PHI priorities for disaster management systems. The next step is a validation of the PHI themes, descriptors and priorities. The result would be a clearer understanding of PHI priorities before, during, and after a disaster. This information will be vital to systematically inform preparation, response, and recovery activities and plans for reducing the risk of disaster exacerbated NCDs through PHI resilience.

Non-communicable disease considerations

The level of attention given to disaster risk reduction activities in mitigating NCDs needs to be accelerated, particularly due to global population aging, increasing obesity and overweight and decreasing physical activity.[11121314] The challenge will be to broaden the focus of disaster management activities for health from response and recovery within the disaster cycle model to a more proactive approach which emphasizes prevention and mitigation.[90] For example, participants described an option that *"...I don't think there's very good pre-planning for an event in relation to those people that do have chronic diseases...(I32)"*. Addressing this will require the health system to increase capacities and relationships across community, non-government, government and service provider sectors (including electricity and telephone companies).[60] The Sendai Framework statement concerning chronic diseases (NCDs) provides the platform for this to occur.[8]

Another consideration beyond the NCDs targeted by this research is the impact disasters may have on drug users and people in drug addiction treatment programs. Research participants discussed the need to consider the impact a breakdown of services or supplies may have on people reliant on methadone and other treatments for drug addiction. Also, evacuation centers and shelters are often ill equipped to address acute drug withdrawals and maintain specialized services for treatment programs.[61] The result is an over reliance on emergency room dosing that lead to unsafe or suboptimal dosing.[62] This issue could be addressed by developing guidance to rapidly verify identification, establish proof of treatment and ascertaining dosage information.[61] By recognizing this challenge, strategies can be developed to ensure drug users and people in drug addiction treatment programs receive the care needed.

Mitigation strategies – implementation

The mitigation strategies presented in Table 5 provide the theoretical basis required for demonstrating how PHI resilience can maximize the treatment and care available for people with NCDs before, during and after a disaster. Although the responder group proposed more strategies than the coordinators and government officials, it is the entire set of strategies that provides the theoretical basis for addressing the problem. The mitigation strategies are interrelated via PHI and if one component fails the health and well-being of people with NCDs will be compromised.

To sustainably implement the mitigation strategies they will need to become integrated into effective performance and monitoring of the disaster response and health sector during non-disaster periods. For this to occur, the strategies should be integrated into business and strategic plans. This could include, for example, identifying a disaster resilient location for back-up treatment and care and working with primary health care facilities to design a hub model of care post-disaster. This approach would ensure PHI disaster resilience, and the benefits this will have for the ongoing care of people with NCDs, is integrated into system-wide policies, plans, programs and budgets.[8]

While sharing of information across agencies about people with NCDs has been identified as a strategy there are ethical and community willingness considerations. For example, in Australia vulnerable persons registers (generally include people with NCDs) are maintained at the local government level and registration is voluntary.[63] The result is often an underestimate of the number of people at risk, for example, in the State

of Victoria, Australia, there are less than 1,350 registered as vulnerable out of a population of just under six million.[64][65] To help address this problem, it is recommended an integrated system be developed that allows local healthcare providers to provide and update information on patients they believe are vulnerable to disaster managers at local government levels. This would occur with permission from the patient.

A collaborative governance approach is required to implement the mitigation strategies due to the wide range of disciplines, organizations and sectors involved.[66] Such an approach would be an amalgamation of organizations beyond the current disaster management system (government agency focus) to allow community and private organizations such as universities, primary health care sector (general practitioners and pharmacies) and transport companies to help solve this problem.[67] The process would include: engaging in comprehensive and shared planning; formal communication across multiple levels; and pooling and jointly acquiring resources to implement the mitigation strategies.[66] This approach would complement the comprehensive, all hazards, all agencies approach to disaster management in Queensland, Australia, and reflect the principles of intersectoral collaboration.[68][69][70]

Finally, the research has presented theoretical strategies for reducing the impact of disasters on the health and well-being of people with NCDs through PHI resilience. Further research needs to be completed to test the effectiveness of the strategies presented. For example, will strategies make a difference by NCD, location and disaster type. This would include working with disaster service providers, primary health care sector, community based organizations and people with NCDs to rank and prioritize the strategies. The result would be strategies which have clearly defined roles, responsibilities and options for enhancing PHI resilience. Ultimately, this will help implement the Sendai Framework and, most importantly, result in sustainable strategies that protect the health of people with NCDs before, during and after a disaster.

Limitations

The research direction was informed by the lead author's professional and research experience in the public health aspects of disasters in Australia at local, state and national levels and across the Asia-Pacific. The lead author has also been part of preparedness and response activities to cyclones that have impacted some of the areas subject to the research. To address this limitation, the second author assisted with the research design and verified the data.

The research was limited to disaster service providers in Queensland, Australia, who have predominately prepared for, and responded to, cyclones, floods and storms in Australia. This group has a vital role in influencing the impact of disasters on PHI and maximizing treatment and care for people with NCDs. This type of role is similar in other parts for the world. For this reason, it is proposed the findings can be transferred to the same disaster types across the world where there are similar disease burdens/trends, however, caution is urged as all systems are unique.

Another potential limitation is that the research was limited to a high-income country setting. Therefore, caution should be taken to applying the findings to low and middle income countries, particularly as the PHI and NCD priorities and challenges may differ.

Conclusion

Disaster service providers can play a vital role in reducing the risk of disaster exacerbated NCDs through PHI resilience. They are often employed in communities where disasters occur and the core elements of their work are directly linked to enhancing PHI resilience to maximize treatment and care at a local level. This combined with the wide range of disciplines demonstrates they can provide the leadership required to systematically expand the focus of disaster systems to include NCDs. Specific measures include: increasing the use of telemedicine; preplanning with medical suppliers; effective town planning; health professionals visiting evacuation centers; evacuation centers having power for medical equipment; hubs for treatment and care after a disaster; evacuation of high risk people prior to disaster; mapping people at risk

by NCD; and a mechanism for sharing information between agencies. To sustainably implement the mitigation strategies they will need to become integrated into effective performance and monitoring of the disaster and health sectors during non-disaster periods. Achieving this will help implement the Sendai Framework and, most importantly, result in sustainable strategies that protect the health of people with NCDs before, during and after a disaster.

Acknowledgements

We thank the participants for taking part in the study.

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Appendix F: Publication 6 – Ranking and prioritizing strategies for reducing mortality and morbidity from noncommunicable diseases post disaster: An Australian perspective

International Journal of Disaster Risk Reduction 27 (2018) 223–228

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr

Ranking and prioritizing strategies for reducing mortality and morbidity from noncommunicable diseases post disaster: An Australian perspective

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ARTICLE INFO

Keywords:
Disaster
Noncommunicable disease
Public health service infrastructure
Disaster preparedness
Queensland
Australia

ABSTRACT

The increasing noncommunicable disease burden and frequency of natural disasters across the world has created an immediate need to implement strategies for reducing the risk of indirect mortality and morbidity post disaster. People at greatest risk of their condition worsening or even death post disaster are those with cancer, cardiovascular conditions, diabetes, renal diseases and respiratory diseases. To help reduce this risk, this study ranked and prioritized mitigation strategies based on the perspectives of people with noncommunicable diseases and disaster responders, coordinators and government officials.

Data was collected through a sequential modified Delphi process in Queensland, Australia. This included three phases: questionnaire (n = 14); workshop (n = 18); and survey (n = 352). Descriptive statistics were used to group differences and to rank and prioritize mitigation strategies.

The research identified 31 mitigation strategies across 12 public health service infrastructure themes. Specific mitigation strategies included: "The need for water treatment plants with back-up power"; "Designated primary healthcare hubs post disaster over health services being designed to be disaster resilient"; and "Streamlining processes for patients to access medication after a disaster". Access to water was the highest priority public health service infrastructure theme followed by the strategies related to communication, sanitation, workforce, supplies.

All mitigation strategies are interrelated and together provide a theoretical basis for addressing this problem. To implement they must be integrated into monitoring and performance measures for the disaster and health sectors during non-disaster periods. The result would be a sustainable approach towards reducing indirect mortality and morbidity from noncommunicable diseases post natural disaster.

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Abbreviations: NCD, noncommunicable disease; NGO, Non government organization; PHI, Public Health Infrastructure; WHO, World Health Organization; ADEA, Australian Diabetes Educators Association

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http://dx.doi.org/10.1016/j.ijdrr.2017.10.009
Received 1 August 2017; Accepted 4 October 2017
Available online 10 October 2017
2212-4209/ Published by Elsevier Ltd.

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Appendix G: Ethics for focus groups and interviews

Ethical approval – James Cook University (H4871)

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Ethical approval – Townsville Hospital and Health Service (HREC/13/QTHS/251)

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Sample letter to organisations – people with non-communicable diseases

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Sample letter to disaster service provider – including environmental health

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Questions

Disaster service providers	**People with NCDs**
1. What experience have you had in disaster management, both professionally and personally?	1. What experience have you had with disasters? a. If experienced, were you diagnosed with your condition before or after the disaster? i. If before, how was the treatment, care and services after the disaster? Did you have an increase in illness/symptoms? ii. If after, what do you believe triggered your condition?
2. Based on this experience, please provide examples of key PHI? a. Why do you consider this as key PHI?	2. What do you see as essential treatment, care and support for your condition?
3. How can PHI impact on NCDs such as cancer, COPD and renal disease?	3. How could a disaster impact on this?
4. From your experience, how can a disaster affect NCDs (e.g. reduced access to pharmaceuticals)?	4. In your opinion, what can be done to enhance your treatment, care and services during and immediately after a disaster?
5. In your opinion, what can be done to mitigate the impact of disasters on NCDs, please provide examples?	5. What is the best approach to surveying other people with NCDs?
6. What is the best method for surveying other providers on this issue?	

Appendix H: Ethics for modified Delphi process

Ethical approval – James Cook University (H6646)

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Sample letter

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Questionnaire

Mitigation Strategies for reducing noncommunicable disease exacerbation

Overview

Please review the following mitigation strategies for maintaining treatment, care and services for someone with a noncommunicable disease (NCD) and indicate whether a strategy should be kept, removed or clarified by ticking the relevant box. Examples of NCDs include: cancer, cardiovascular diseases, diabetes, mental health conditions, respiratory disease and renal diseases.

The strategies have been grouped by theme, which include: communication, equipment, finance, governance, physical structure, power, prevention, sanitation, services, supplies, surveillance, transport, water and workforce.

Please feel free to recommend additional strategies.

Strategies

1. Communication

Strategy	**Keep**	**Remove**	**Clarification required**
Brochures about how to maintain your health and wellbeing located at evacuation centres and shelters			
Central contact point for people with NCDs			
Consistent and clear messages about where people can go for assistance after a disaster			
Information about preparedness for people with NCDs in rates notices and on Council websites			

Regular disaster warnings and reminders via SMS; Facebook; Twitter; radio; television			
Targeted preparedness messaging to people with NCDs			
Local disaster groups coordinate preparedness communication for people with NCDs			
Portable mobile phone towers			
Back-up power provided to the telephone exchange			
Other (write-in):			

2. Equipment

Strategy	**Keep**	**Remove**	**Clarification required**
People with NCDs having back-up equipment (spare oxygen cylinders)			
Waterproof treatment kits			
Health services maintain surplus equipment during disaster season			
Other (write-in):			

3. Finance

Strategy	Keep	Remove	Clarification required
Mobile ATMs positioned in disaster affected areas			
Banks capable of opening immediately post disaster			
Rapid deployment of officials to provide financial aid			
Other (write-in):			

4. Physical structure

Strategy	Keep	Remove	Clarification required
Store back-up medication in a secure location			
Hubs for treatment, care and services set up around schools, evacuation centres and shelters			
Providing people with NCDs a purpose-built facility to maintain treatment during a disaster			
Health services designed to be disaster resilient			

Safe storage for fuel			
Other (write-in):			

5. Governance

Strategy	**Keep**	**Remove**	**Clarification required**
Annual community-wide day of readiness for disasters			
Educating the community on how to assist a person with medical issues after a disaster			
Encouraging personal responsibility for disaster preparedness			
Health representation at disaster management groups			
Interagency planning for maintaining treatment, care and services			
Locally led planning, response and recovery			
Plans for people who cannot self-medicate at home			
Provide a centralised system for coordinating transport to treatment, care and services			

Resilient communication between health services and disaster management groups			
Private practices have plans to reduce reliance on the hospital system after a disaster			
Other (write-in):			

6. Power

Strategy	**Keep**	**Remove**	**Clarification required**
Back-up power for people reliant on medical equipment (for example, home oxygen patients)			
General Practitioner clinics with back-up power			
Provide charging stations for medical equipment at evacuation centres			
Other (write-in):			

7. Prevention

Strategy	**Keep**	**Remove**	**Clarification required**
Patients having a list of emergency contacts			
Education led by the agency providing care to people with NCDs			
Evacuate people with NCDs who are most vulnerable			
Clinicians work with patients to develop disaster plans			
People with NCDs understanding their vulnerabilities			
Systems in-place to allow people with NCDs to return home as soon as possible after a disaster			
Include people with NCDs in disaster exercises			
Clinicians encourage patients to discuss disaster planning with their family			
Town planning to reduce the vulnerability of health services to a disaster			
Regular audits of disaster preparedness activities such as maintenance of generators, equipment and telecommunication systems			

Other (write-in):			

8. Sanitation

Strategy	**Keep**	**Remove**	**Clarification required**
Prioritise access to safe water for people with NCDs			
Good hygiene practices implemented at evacuation centres and shelters			
Good hygiene practices in the home environment			
Evacuate people with NCDs who are at an increased risk of infection from poor sanitation standards post disaster			
Food businesses maintaining good hygiene standards			
Other (write-in):			

9. Services

Strategy	**Keep**	**Remove**	**Clarification required**
Streamlining processes for patients to access medication after a disaster			
Access to telemedicine after a disaster			

General Practitioners having plans in-place to resume services immediately after a disaster			
Health professionals visit evacuation centres and other mass gathering locations			
Provide treatment, care and services at multiple sites			
Provide emergency child care for clinician families post disaster			
Other (write-in):			

10. Supplies

Strategy	**Keep**	**Remove**	**Clarification required**
Plans to rapidly deploy medication to impacted communities			
Health services maintain surplus medication supplies during disaster season			
Nutritious food options provided at evacuation centres and shelters			
Patients bring medication to evacuation centres			
Other (write-in):			

11. Surveillance

Strategy	Keep	Remove	Clarification required
Central registration point for people with NCDs			
Community-wide mapping of people with NCDs			
General Practitioners forwarding details of patients most at risk to local disaster groups prior to a disaster			
Readily accessible data for disaster groups on the treatment trends and needs of a community			
Other (write-in):			

12. Transport

Strategy	Keep	Remove	Clarification required
Evacuation of high-risk people prior to disaster			
Use boats as an alternate option for transporting patients			
Use planes to transport patients			
Use helicopters to transport patients			

Buses used to transport patients			
Other (write-in):			

13. Water

Strategy	**Keep**	**Remove**	**Clarification required**
Evacuation of people with NCDs who are reliant on safe water for treatment			
Water purification plant with back-up power			
Alternate water supply for people with NCDs (e.g. bottled water or rainwater tanks)			
Other (write-in):			

14. Workforce

Strategy	**Keep**	**Remove**	**Clarification required**
Health professionals contacting patients after a disaster			
Health professionals provide telemedicine care for patients impacted by disaster			

Health professionals to visit evacuation centres and other mass gatherings after a disaster			
Rapid deployment of health professionals to areas impacted by a disaster			
Staff trained in disaster management systems			
Rapid deployment of health professionals to areas impacted by a disaster			
Access to tradespeople to maintain equipment and physical structures post disaster			
Other (write-in):			

Survey

Strategies for reducing disaster exacerbated non-communicable diseases

---

Page description:
Please note: Throughout the survey all questions, except free text, require a response before you can progress to the next page

1. Gender *

- Male
- Female
- Prefer not to answer

2. Age group *

- 18 to 24
- 25 to 34
- 35 to 44
- 45 to 54
- 55 to 64
- 65 or older
- Prefer not to answer

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LOGIC Show/hide trigger exists.

3. Do you have a non-communicable disease?
(For example, cancer, cardiovascular, diabetes, mental health, renal disease or respiratory condition) *

- ○ Yes
- ○ No

LOGIC Show/hide trigger exists.

4. Are you involved in disaster management in a professional or volunteer capacity? *

- ○ Yes
- ○ No

(untitled)

5. Which region best describes where you live? *

- ○ Brisbane
- ○ Cairns and Hinterland
- ○ Toowoomba
- ○ Townsville
- ○ Other (please write-in)

LOGIC Hidden unless: Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes")

6. Which geographical region best describes your area of work/responsibility? *

- Brisbane
- Cairns and Hinterland
- Toowoomba
- Townsville
- State-wide (Queensland)
- Other (please write-in)

LOGIC Show/hide trigger exists.

7. Have you experienced a natural disaster? *

- Yes
- No

LOGIC Hidden unless: Question "Have you experienced a natural disaster?" #7 is one of the following answers ("Yes")

8. What type of natural disaster have you experienced?

(Please note: you can select more than one response) *

- [ ] Bushfire
- [ ] Cyclone
- [ ] Earthquake
- [ ] Flood
- [ ] Tornado
- [ ] Tsunami
- [ ] Other

(untitled)

LOGIC Show/hide trigger exists. Hidden unless: Question "Do you have a non-communicable disease?
(For example, cancer, cardiovascular, diabetes, mental health, renal disease or respiratory condition)" #3 is one of the following answers ("Yes")

9. What type of non-communicable disease do you have?
(Please note: you can select more than one condition) *

- [ ] Cancer
- [ ] Cardiovascular disease
- [ ] Diabetes
- [ ] Mental health
- [ ] Renal disease
- [ ] Respiratory condition
- [ ] Other (please write-in)

LOGIC Hidden unless: Question "Do you have a non-communicable disease?
(For example, cancer, cardiovascular, diabetes, mental health, renal disease or respiratory condition)" #3 is one of the following answers ("Yes")

10. Are you dependent on help from others to manage your condition (e.g. carer, family or friend)? *

- ○ Yes
- ○ No
- ○ Sometimes

LOGIC Hidden unless: Question "Do you have a non-communicable disease? *(For example, cancer, cardiovascular, diabetes, mental health, renal disease or respiratory condition)*" #3 is one of the following answers ("Yes")

11. What signs and symptoms are you most worried about after a disaster? *(You can select more than one response)* *

- ☐ Chest infection
- ☐ Chest pain or discomfort
- ☐ Chronic pain
- ☐ Diarrhea
- ☐ Excessive thirst
- ☐ Hypoglycemia (low blood sugar level)
- ☐ Increased hunger
- ☐ Loss of sleep
- ☐ Nausea and vomiting
- ☐ Numbness or swelling in the hands and feet
- ☐ Shortness of Breath
- ☐ Slow-healing sores
- ☐ Stress and anxiety
- ☐ Weakness or fatigue
- ☐ Other (please write-in)

(untitled)

LOGIC Hidden unless: Question "Do you have a non-communicable disease? *(For example, cancer, cardiovascular, diabetes, mental health, renal disease or respiratory condition)*" #3 is one of the following answers ("Yes")

12. **During and after a disaster**, what would be the importance of the following infrastructure/systems to manage your condition?
If you require further clarification of a term, please hover the mouse cursor over the word 'examples'. *

	N/A	Low	Medium	High
Communication (examples)Internet; telephone; mobile phone; and media.	○	○	○	○
Equipment (examples)Beds; medical devices; hand washing facilities; refrigerators; and water pumps.	○	○	○	○
Finance (examples)ATM; bank; and money.	○	○	○	○
Governance (examples)Agreements; command and control, coordination; disaster system; funding; government; law enforcement; and planning.	○	○	○	○
Physical structure (examples)Buildings; storage facilities; health facilities; and shelters.	○	○	○	○
Power (examples)Electricity; energy supply; and power lines.	○	○	○	○
Prevention (examples) Education about disaster preparedenss; general health promotion; and public health programs such as vaccination.	○	○	○	○
Sanitation (examples)Infection control; sewage systems; waste management; wastewater; and water treatment.	○	○	○	○
Services (examples)Businesses; clinics; pharmacies; and utilities.	○	○	○	○
Supplies (examples)Food; fuel; gas; medications; and water sources.	○	○	○	○
Surveillance (examples)Assessments; monitoring; health data; and health information systems.	○	○	○	○
Transport (examples)Airport; bridges; footpath access; roads; and general transport such as cars.	○	○	○	○
Water (examples)Dams; drinking water; and water supply.	○	○	○	○
Workforce (examples)Doctors; nurses; allied health; and other health professionals.	○	○	○	○

(untitled)

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LOGIC Hidden unless: Question "What type of non-communicable disease do you have? *(Please note: you can select more than one condition)*" #9 is one of the following answers ("Cancer","Cardiovascular disease","Diabetes","Mental health","Renal disease","Respiratory condition","Other (please write-in)")

13. Within the **first week after a disaster (0-7 days)**, what aspects of your treatment and care would you be most worried about?

LOGIC Hidden unless: Question "What type of non-communicable disease do you have? *(Please note: you can select more than one condition)*" #9 is one of the following answers ("Cancer","Cardiovascular disease","Diabetes","Renal disease","Respiratory condition","Mental health","Other (please write-in)")

14. **One to four weeks after a disaster (8-28 days)**, what aspects of your treatment and care would you be most worried about?

(untitled)

LOGIC Hidden unless: Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes")

15. Which sector best describes your employer for disaster management activities? *

- ○ Government
- ○ Not for profit
- ○ Private sector
- ○ Other (please write-in)

LOGIC Hidden unless: Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes")

16. What is your role in disaster management?

(Please note: you can select more than one response) *

- [ ] Administration Officer
- [ ] Environmental Health Officer
- [ ] Firefighter
- [ ] Director
- [ ] Disaster Coordinator/Planner
- [ ] Doctor
- [ ] Emergency Services
- [ ] Manager
- [ ] Military
- [ ] Nurse
- [ ] Paramedic
- [ ] Police Officer
- [ ] Public Health Officer
- [ ] Volunteer (please write-in role)
- [ ] Other (please write-in role)

(untitled)

LOGIC Hidden unless: Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes")

17. Within the **first week after a disaster (0-7 days)**, what is the likelihood that you will be involved in the management of people with the following non-communicable diseases? *

	Never	Low	Medium	High
Cancer	○	○	○	○
Cardiovascular disease	○	○	○	○
Diabetes	○	○	○	○
Mental health	○	○	○	○
Renal disease	○	○	○	○
Respiratory condition	○	○	○	○

LOGIC Hidden unless: Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes")

18. **One to four weeks after a disaster (8-28 days)**, what is the likelihood that you will be involved in the management of people with the following non-communicable diseases? *

	Never	Low	Medium	High
Cancer	○	○	○	○
Cardiovascular disease	○	○	○	○
Diabetes	○	○	○	○
Mental health	○	○	○	○
Renal disease	○	○	○	○
Respiratory condition	○	○	○	○

(untitled)

LOGIC Hidden unless: Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes")

19. **During and immediately after a disaster**, how important would the following infrastructure/systems be for maintaining treatment and care for people with non-communicable diseases?
If you require further clarification of a term, please hover the mouse cursor over the word 'examples'. *

	N/A	Low	Medium	High
Communication (examples)Internet; telephone; mobile phone; and media.	○	○	○	○
Equipment (examples)Beds; medical devices; hand washing facilities; refrigerators; and water pumps.	○	○	○	○
Finance (examples)ATM; bank; and money	○	○	○	○
Governance (examples)Agreements; command and control, coordination; disaster system; funding; government; law enforcement; and planning.	○	○	○	○
Physical structure (examples)Buildings; storage facilities; health facilities; and shelters.	○	○	○	○
Power (examples)Electricity; energy supply; and power lines.	○	○	○	○
Prevention (examples) Education about disaster preparedenss; general health promotion; and public health programs such as vaccination.	○	○	○	○
Transport (examples)Airport; bridges; footpath access; roads; and general transport such as cars.	○	○	○	○
Sanitation (examples)Infection control; sewage systems; waste management; wastewater; and water treatment.	○	○	○	○
Services (examples)Businesses; clinics; pharmacies; and utilities.	○	○	○	○
Supplies (examples)Food; fuel; gas; medications; and water sources.	○	○	○	○
Surveillance (examples)Assessments; monitoring; health data; and health information systems.	○	○	○	○
Water (examples)Dams; drinking water; and water supply.	○	○	○	○
Workforce (examples)Doctors; nurses; allied health; and other health professionals.	○	○	○	○

VALIDATION **Min. answers = 11** *(if answered)*

LOGIC Hidden unless: (Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes") AND Question "Communication (examples)Internet; telephone; mobile phone; and media." is one of the following answers ("High"))

20. You rated **communication** as 'high' in importance for maintaining treatment and care. Please rate the effectiveness of the following mitigation strategies.

Please note:

- A mitigation strategy is the lessening or limitation of the adverse impacts of hazards and related disasters.

- Additional strategies can be written into the cell titled 'Enter another option'.

- All questions, except 'Enter another option', require a response before you can progress to the next page. *

	N/A	Low	Medium	High	Strategy requires further clarification
Regular disaster warnings and reminders via SMS; Facebook; Twitter; radio; television	○	○	○	○	○
State Government lead development of preparedness messages for people with NCDs	○	○	○	○	○
Information about preparedness for people with NCDs on Council websites	○	○	○	○	○
Consistent and clear messages about where people can go for assistance after a disaster	○	○	○	○	○
Back-up power provided to the telephone exchange	○	○	○	○	○
Targeted preparedness messaging to people with NCDs	○	○	○	○	○
Information about where to receive treatment and care post disaster available at evacuation centres and shelters	○	○	○	○	○
Brochures about how to maintain your health and well-being located at evacuation centres and shelters	○	○	○	○	○
Portable mobile phone towers	○	○	○	○	○
Information about preparedness activities available from GPs, support groups and specialists	○	○	○	○	○
Local health service facilitates preparedness messages for people with NCDs	○	○	○	○	○

(untitled)

VALIDATION **Min. answers = 3** *(if answered)*

HIDDEN Hidden unless: (Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes") AND Question "Equipment (examples)Beds; medical devices; hand washing facilities; refrigerators; and water pumps." is one of the following answers ("High"))

21. You rated **equipment** as 'high' in importance for maintaining treatment and care. Please rate the effectiveness of the following mitigation strategies.

Please note:

- A mitigation strategy is the lessening or limitation of the adverse impacts of hazards and related disasters.

- Additional strategies can be written into the cell titled 'Enter another option'.

- All questions, except 'Enter another option', require a response before you can progress to the next page. *

	N/A	Low	Medium	High	Strategy requires further clarification
People with NCDs having back-up equipment (for example, spare oxygen cylinders and generator)	○	○	○	○	○
Health services have plans in-place to rapidly source the equipment required to treat people with NCDs	○	○	○	○	○
Storage of equipment in waterproof containers	○	○	○	○	○

(untitled)

VALIDATION **Min. answers = 3** *(if answered)*

LOGIC Hidden unless: (Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes") AND Question "Finance (examples)ATM; bank; and money " is one of the following answers ("High"))

22. You rated **finance** as 'high' in importance for maintaining treatment and care. Please rate the effectiveness of the following mitigation strategies.

Please note:

- A mitigation strategy is the lessening or limitation of the adverse impacts of hazards and related disasters.

- Additional strategies can be written into the cell titled 'Enter another option'.

- All questions, except 'Enter another option', require a response before you can progress to the next page. *

	N/A	Low	Medium	High	Strategy requires further clarification
Mobile ATMs positioned in disaster affected areas	○	○	○	○	○
Banks have capability to open immediately after a disaster	○	○	○	○	○
Rapid deployment of government officials to provide financial support	○	○	○	○	○

(untitled)

VALIDATION **Min. answers = 9** *(if answered)*

LOGIC Hidden unless: (Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes") AND Question "Governance (examples)Agreements; command and control, coordination; disaster system; funding; government; law enforcement; and planning." is one of the following answers ("High"))

23. You rated **governance** as 'high' in importance for maintaining treatment and care. Please rate the effectiveness of the following mitigation strategies.
Please note:
- A mitigation strategy is the lessening or limitation of the adverse impacts of hazards and related disasters.
- Additional strategies can be written into the cell titled 'Enter another option'.
- All questions, except 'Enter another option', require a response before you can progress to the next page. *

	N/A	Low	Medium	High	Strategy requires further clarification
Annual community-wide day of readiness for disasters	○	○	○	○	○
Educating the community on how to assist a person with medical issues after a disaster	○	○	○	○	○
Encouraging personal responsibility for disaster preparedness	○	○	○	○	○
Health representation at disaster management groups	○	○	○	○	○
Interagency planning for maintaining treatment and care	○	○	○	○	○
Locally led planning, response and recovery	○	○	○	○	○
Provide a centralised system for coordinating transport to treatment and care	○	○	○	○	○
Multiple communication methods between health services and disaster management groups	○	○	○	○	○
Private practices have plans to reduce reliance on the hospital system after a disaster	○	○	○	○	○

(untitled)

VALIDATION **Min. answers = 5** *(if answered)*

LOGIC Hidden unless: (Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes") AND Question "Physical structure (examples)Buildings; storage facilities; health facilities; and shelters." is one of the following answers ("High"))

24. You rated **physical structure** as 'high' in importance for maintaining treatment and care. Please rate the effectiveness of the following mitigation strategies.

Please note:

- A mitigation strategy is the lessening or limitation of the adverse impacts of hazards and related disasters.

- Additional strategies can be written into the cell titled 'Enter another option'.

- All questions, except 'Enter another option', require a response before you can progress to the next page. *

	N/A	Low	Medium	High	Strategy requires further clarification
Store back-up medication in a secure location	○	○	○	○	○
Designated primary healthcare hubs post disaster	○	○	○	○	○
Providing people with non-communicable diseases a purpose built facility to maintain treatment during a disaster	○	○	○	○	○
Health services designed to be disaster resilient	○	○	○	○	○
Safe storage for fuel	○	○	○	○	○

(untitled)

VALIDATION **Min. answers = 3** *(if answered)*

LOGIC Hidden unless: (Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes") AND Question "Power (examples)Electricity; energy supply; and power lines." is one of the following answers ("High"))

25. You rated **power** as 'high' in importance for maintaining treatment and care. Please rate the effectiveness of the following mitigation strategies.

Please note:

- A mitigation strategy is the lessening or limitation of the adverse impacts of hazards and related disasters.

- Additional strategies can be written into the cell titled 'Enter another option'.

- All questions, except 'Enter another option', require a response before you can progress to the next page. *

	N/A	Low	Medium	High	Strategy requires further clarification
Back-up power for people reliant on medical equipment (for example, home oxygen patients)	○	○	○	○	○
General Practitioner clinics with back-up power	○	○	○	○	○
Provide charging stations for medical equipment at evacuation centres	○	○	○	○	○

[untitled)

VALIDATION **Min. answers = 10** *(if answered)*

LOGIC Hidden unless: (Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes") AND Question "Prevention (examples) Education about disaster preparedenss; general health promotion; and public health programs such as vaccination." is one of the following answers ("High"))

26. You rated **prevention** as 'high' in importance for maintaining treatment and care. Please rate the effectiveness of the following mitigation strategies.

Please note:

- A mitigation strategy is the lessening or limitation of the adverse impacts of hazards and related disasters.

- Additional strategies can be written into the cell titled 'Enter another option'.

- All questions, except 'Enter another option', require a response before you can progress to the next page. *

	N/A	Low	Medium	High	Strategy requires further clarification
Education led by the agency providing care to people with NCDs	○	○	○	○	○
People with NCDs understanding their vulnerabilities	○	○	○	○	○
Systems in-place to allow people with NCDs to return home as soon as possible after a disaster	○	○	○	○	○
Consider the needs of people with NCDs during disaster exercises	○	○	○	○	○
As a last resort, evacuate people with NCDs who cannot access essential care	○	○	○	○	○
Town planning to reduce the vulnerability of health services to a disaster	○	○	○	○	○
Patients having a list of emergency contacts	○	○	○	○	○
Regular audits of disaster preparedness activities such as maintenance of generators, equipment and telecommunication systems	○	○	○	○	○
Clinicians encourage patients to discuss disaster planning with their family	○	○	○	○	○
Proactively evacuate people with NCDs who may not be able to access essential care post disaster	○	○	○	○	○

VALIDATION **Min. answers = 5** *(if answered)*

LOGIC Hidden unless: (Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes") AND Question "Sanitation (examples):Infection control; sewage systems; waste management; wastewater; and water treatment." is one of the following answers ("High"))

27. You rated **sanitation** as 'high' in importance for maintaining treatment and care. Please rate the effectiveness of the following mitigation strategies.

Please note:

- A mitigation strategy is the lessening or limitation of the adverse impacts of hazards and related disasters.

- Additional strategies can be written into the cell titled 'Enter another option'.

- All questions, except 'Enter another option', require a response before you can progress to the next page. *

	N/A	Low	Medium	High	Strategy requires further clarification
Food businesses maintaining good hygiene standards	○	○	○	○	○
Community-wide messages about the need to maintain good hygiene practices in the home environment	○	○	○	○	○
Prioritise access to safe water for people with NCDs	○	○	○	○	○
Evacuate people with NCDs who are at an increased risk of infection from poor sanitation standards post disaster	○	○	○	○	○
Good hygiene practices implemented at evacuation centres and shelters	○	○	○	○	○

(untitled)

VALIDATION **Min. answers = 6** *(if answered)*

LOGIC Hidden unless: (Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes") AND Question "Services (examples)Businesses; clinics; pharmacies; and utilities." is one of the following answers ("High"))

28. You rated **services** as 'high' in importance for maintaining treatment and care. Please rate the effectiveness of the following mitigation strategies.

Please note:

- A mitigation strategy is the lessening or limitation of the adverse impacts of hazards and related disasters.

- Additional strategies can be written into the cell titled 'Enter another option'.

- All questions, except 'Enter another option', require a response before you can progress to the next page. *

	N/A	Low	Medium	High	Strategy requires further clarification
Streamlining processes for patients to access medication after a disaster	○	○	○	○	○
Provide treatment and care at multiple sites	○	○	○	○	○
Health professionals visit evacuation centres and other mass gathering locations	○	○	○	○	○
Provide emergency child care for clinician families post-disaster	○	○	○	○	○
General Practitioners having plans in-place to resume services immediately after a disaster	○	○	○	○	○
Access to telemedicine after a disaster	○	○	○	○	○

(untitled)

VALIDATION **Min. answers = 6** *(if answered)*

HIDDEN Hidden unless: (Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes") AND Question "Supplies (examples)Food; fuel; gas; medications; and water sources." is one of the following answers ("High"))

29. You rated **supplies** as 'high' in importance for maintaining treatment and care. Please rate the effectiveness of the following mitigation strategies.

Please note:

- A mitigation strategy is the lessening or limitation of the adverse impacts of hazards and related disasters.

- Additional strategies can be written into the cell titled 'Enter another option'.

- All questions, except 'Enter another option', require a response before you can progress to the next page. *

	N/A	Low	Medium	High	Strategy requires further clarification
Health services have a surplus of consumables during disaster season	○	○	○	○	○
People who a reliant on a specific diet bring their own food to evacuation centres and shelters	○	○	○	○	○
Pharmacies identify options for rapidly sourcing additional consumables to treat people with NCDs	○	○	○	○	○
Patients bring medication to evacuation centres	○	○	○	○	○
Plans to rapidly deploy medication to impacted communities	○	○	○	○	○
Health services identify options for rapidly sourcing additional consumables to treat people with NCDs	○	○	○	○	○

(untitled)

VALIDATION **Min. answers = 3** *(if answered)*

LOGIC Hidden unless: (Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes") AND Question "Surveillance (examples)Assessments; monitoring; health data; and health information systems." is one of the following answers ("High"))

30. You rated **surveillance** as 'high' in importance for maintaining treatment and care. Please rate the effectiveness of the following mitigation strategies.

Please note:

- A mitigation strategy is the lessening or limitation of the adverse impacts of hazards and related disasters.

- Additional strategies can be written into the cell titled 'Enter another option'.

- All questions, except 'Enter another option', require a response before you can progress to the next page. *

	N/A	Low	Medium	High	Strategy requires further clarification
Community-wide mapping of people with NCDs	○	○	○	○	○
General Practitioners forwarding details of patients most at risk to local disaster groups prior to a disaster	○	○	○	○	○
Readily accessible data for disaster groups on the treatment trends and needs of a community	○	○	○	○	○

(untitled)

VALIDATION **Min. answers = 5** *(if answered)*

LOGIC Hidden unless: (Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes") AND Question "Transport (examples)Airport; bridges; footpath access; roads; and general transport such as cars." is one of the following answers ("High"))

31. You rated **transport** as 'high' in importance for maintaining treatment and care. Please rate the effectiveness of the following mitigation strategies.

Please note:

- A mitigation strategy is the lessening or limitation of the adverse impacts of hazards and related disasters.

- Additional strategies can be written into the cell titled 'Enter another option'.

- All questions, except 'Enter another option', require a response before you can progress to the next page. *

	N/A	Low	Medium	High	Strategy requires further clarification
Use helicopters to transport patients	○	○	○	○	○
Use boats as an alternate option for transporting patients	○	○	○	○	○
Use planes to transport patients	○	○	○	○	○
Evacuation of high-risk people prior to disaster	○	○	○	○	○
Buses used to transport patients	○	○	○	○	○

(untitled)

VALIDATION **Min. answers = 6** *(if answered)*

LOGIC Hidden unless: (Question "Are you involved in disaster management in a professional or volunteer capacity?" #4 is one of the following answers ("Yes") AND Question "Workforce (examples)Doctors; nurses; allied health; and other health professionals." is one of the following answers ("High"))

33. You rated **workforce** as 'high' in importance for maintaining treatment and care. Please rate the effectiveness of the following mitigation strategies.

Please note:

- A mitigation strategy is the lessening or limitation of the adverse impacts of hazards and related disasters.

- Additional strategies can be written into the cell titled 'Enter another option'.

- All questions, except 'Enter another option', require a response before you can progress to the next page. *

	N/A	Low	Medium	High	Strategy requires further clarification
Staff trained in disaster management systems	○	○	○	○	○
Health professionals provide telemedicine care for patients impacted by disaster	○	○	○	○	○
Access to tradespeople to maintain equipment and physical structures post disaster	○	○	○	○	○
Health professionals contacting patients after a disaster	○	○	○	○	○
Rapid deployment of health professionals to areas impacted by a disaster	○	○	○	○	○
Health professionals to visit evacuation centres and other mass gatherings after a disaster	○	○	○	○	○

(untitled)

34. Thank you for completing the survey. Do you have any comments or suggestions? If so, please describe below: