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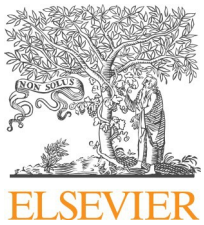

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Barriers and facilitators to burn first aid practice in the prehospital setting: A qualitative investigation amongst emergency medical service clinicians

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ABSTRACT

First aid cooling for burn injuries improves re-epithelialisation rates and reduces scarring. The objective of this research was to explore and describe barriers and facilitators to the provision of optimal first aid for acute burn patients in the prehospital setting. Emergency medical service (EMS) clinicians in Queensland were invited via email to participate in a survey designed to assess experience, knowledge, and attitudes regarding provision of optimal burn first aid in the prehospital setting (N = 4500). Barriers and facilitators to administering optimal first aid in the prehospital environment were assessed via two open-ended questions with free-text response boxes. An inductive approach to qualitative content analysis was used to analyze free-text data. In total, we included 326 respondents (7.2% response rate). Responses (n = 231) regarding barriers to first aid were classified into 12 categories, within five overarching dimensions. The most common of these was identified as pain. Similarly, free text responses (n = 276) regarding facilitators of burn first aid formed eight dimensions with 21 subcategories – most commonly fast and effective pain relief. Factors influencing burn first aid provision in the prehospital setting were wide-ranging and varied, with pain identified as the most prominent.

Abbreviations: EMS, emergency medical service; CRW, cool running water; QAS, Queensland Ambulance Service; ED, emergency department; QCA, qualitative content analysis; LASN, local ambulance service networks; HBD, hydrogel burn dressing; IV, intravenous

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1. Introduction

Burn injuries are a common form of trauma in Australia and New Zealand, for both adult and pediatric populations, with over 3484 patient admissions to specialized burn units between 2020 and 2021 [1]. Twenty-six percent of pediatric patients (aged between 0 and 16 years) admitted to these specialized burn units did not receive adequate first aid for their burn injuries [1]. This figure was even higher for adults, with 39% of patients receiving no or inadequate first aid for their burns [1]. Recommended gold standard first aid for thermal burn injuries consists of 20-minutes of cool running water (CRW) administered within three hours of the burn occurring [2] – in accordance with the European Burns Association [3], British Burns Association [4,5], and the Australian and New Zealand Burns Association [6]. Burn first aid is critical for preventing further tissue damage, improving time to re-epithelialization, and improving long-term scar outcomes [2,7–11]. Cool running water has also been shown to reduce skin graft use for pediatric patients – with a 44% reduction in skin graft rates for children who received optimal first aid in comparison to patients who did not receive 20-minutes CRW [12]. This association has also been documented in adult patients – with significant reductions in burn surface area, depth, and grafting observed in patients who received first aid within 3 h [13].

Findings from a prospective cohort study conducted in Western Australia identified that, whilst running water first aid was documented in 68% of burn patients, only 48% of patients received CRW for the recommended 20-minute duration within three hours post-burn [14]. For those burn patients who did receive CRW for 20-minutes, a 13% reduction in the need for skin grafting was observed. Moreover, this investigation reported a 48% reduced likelihood of intensive care unit admission in patients who received 20-minutes CRW within three hours compared to those who received no first aid [14]. In a similar cohort investigation of $n = 4918$ burn patients from New South Wales, it was determined that over 58% of patients received gold standard burn first aid. Patients who received CRW for 20-minutes within three hours had a significant reduction in burn wound depth, as well as a significant reduction in time to re-epithelialization [15]. In Queensland, Australia, clinical practice guidelines for the prehospital treatment of acute burns call for active cooling with running water for 20 min; protection against hypothermia (i.e., cool the burn, warm the patient); and early assessment and management of airways if indicated [16]. Following 20-minutes CRW, prehospital guidelines recommend covering acute burns with plastic wrap to maintain a moist wound environment, minimize infection risk, and prevent air currents passing over exposed nerve endings in the dermis [17].

The nature and timing of burn first aid is a critical determinant of patient outcomes – impacting the progression of the burn and final scar appearance. Recent reports however indicate that first aid interventions, in particular rates of CRW first aid, often fall short of the recommended standard of 20-minutes applied within 3 h of the initial burn [18–24]. In a retrospective audit of electronic ambulance records from 2008 to 2010 of pediatric burn patients (0 – 5 years) who received prehospital burn care, it was determined that 56.4% of children with acute burns received CRW [18]. In a similar retrospective review using data from $n = 4268$ pediatric burn patients presenting to a major Burns Unit in Australia, no or inadequate first aid cooling was reported in 34% of inpatients and 30% of pediatric burn outpatients [20]. A prospective longitudinal review of pediatric and adult burn data, conducted in a remote Australian hospital context, found that 24% of patients had no CRW for their burns [22]. In this investigation, just over 40% of burn patients received gold standard burn first aid – defined as 20-minutes CRW within three hours [22].

Past research has explored rates of burn first aid knowledge in particular patient populations [25–28] and health care workers [29], however few studies have explored Emergency Medical Service (EMS) clinician attitudes regarding burn first aid administration, and specifically regarding facilitators and barriers to administering CRW first aid in the prehospital setting. Due to the substantial impact provision of optimal burn first aid has on clinical and long-term patient outcomes, it is critical that we increase our understanding of contextual limitations and barriers to the provision of 20-minutes CRW for acute burn injuries in the prehospital environment. The aim of this research was to explore and describe barriers and facilitators experienced by EMS clinicians when administering first aid to acute burn patients in the prehospital setting.

2. Material and methods

This investigation used a qualitative research design to describe and explore barriers to the provision of prehospital burn first aid for EMS clinicians. An online 30-item purpose-built questionnaire was developed and disseminated to EMS clinicians via SurveyPlanet™ (SurveyPlanet LLC. California, USA). Participants comprised EMS clinicians employed by Queensland Ambulance Service (QAS) at the time of recruitment (2019). In Queensland, prehospital emergency care is provided by the QAS, which is a single, statewide government-funded emergency ambulance service that responds to over one million incidents annually. Queensland Ambulance Service provides emergency and non-emergency prehospital patient care and specialized transport services as well as casualty room services and coordination of multi-casualty incidents and disasters. Queensland is a northeastern state in Australia, with an estimated population of 5.25 million people. It is the second largest state in the country – with an extremely diverse range of geographical features and climates. Participants were recruited as part of a large prospective qualitative investigation exploring burn first aid knowledge and attitudes amongst EMS clinicians. An email with an invitation to participate in the research (including a link to the online questionnaire) was sent to all EMS clinicians within QAS ($N = 4500$) in October 2019, who were given one month to respond. Participation was voluntary and anonymous. Ethics approval was obtained from the Children's Health Queensland Human Research Ethics Committee (HREC/16/QRCH/322) and endorsement from the QAS Research and Innovation Committee (Ref: 19/00058). Informed consent was obtained from all participants prior to completing the online questionnaire.

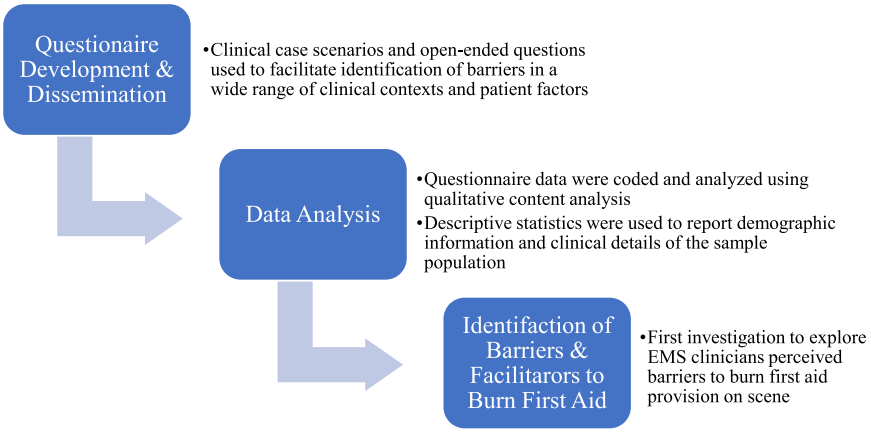

Fig. 1 – Research Process Overview.

The 30-item purpose-built electronic questionnaire included sections on demographics, burn clinical case scenarios, experience in burn first aid administration in the prehospital setting, and two free text items on barriers and enablers to providing adequate burn first aid (full questionnaire provided in Appendix A). Questions were adapted from a 2005 investigation, which examined burn first aid knowledge amongst Western Australian health care workers [29]. The purpose-built questionnaire was developed in collaboration with senior burns surgeons and emergency department (ED) nursing staff at a major tertiary pediatric hospital – and was tested and piloted prior to deployment. Burn first aid knowledge and EMS clinician attitudes towards different acute burn dressings are described elsewhere [30]. This paper reports factors that impact EMS clinician provision of CRW first aid in the prehospital setting. The two open-ended free text items urged participants to describe barriers faced when providing first aid for acute patients, and facilitators of optimal first aid. Demographic data collected included age, education level, QAS rank, how long participants had worked as an EMS clinician, work region within Queensland, and previous experience treating adult and pediatric burn patients.

2.1. *Qualitative content analysis*

An inductive approach to conventional qualitative content analysis (QCA) was used to assess responses to the two free-text items [31]. This is a method used to generate subjective interpretation of the content of free text data using methodical classification processes of coding and the identification of themes and/or patterns [31,32]. Coding aims to summarize large quantities of free-text data into fewer content categories that reflect themes and patterns, which are expressed within the text data, or are derived from text data. The first phase of QCA is familiarizing and immersing oneself in the data [33]. This phase involves repeated readings of all free-text responses to develop an understanding of the content of the data – and beginning an active search for patterns and meanings. The second phase of QCA involves the initial generation of codes [33]. To develop a coding framework, a random sample of 100 free-text responses were read to determine predominant themes regarding barriers and facilitators to first aid. Codes were generated until no new themes emerged, and data thickness and richness was achieved (i.e. data saturation) [34].

Phase three of QCA involved searching for categories [33]. Following the generation of initial codes, all text data were then re-read and re-coded to develop patterns. The developed codes were reassembled and grouped into overarching categories. Modifications to codes were made until consensus was reached. In phase four of QCA, the devised categories were reviewed and refined. In accordance with Nowell and colleagues (2017), the refinement of categories occurred until categories were specific and discrete, but also broad enough to capture ideas from multiple free-text responses [33]. The fifth and final phase of QCA involved defining and naming categories, and the development of dimensions to create a hierarchical structure [33]. In order to establish agreement between researchers, and enhance the trustworthiness of the findings, peer debriefing was undertaken and two researchers provided feedback on data interpretation and identified categories and dimensions (investigator-triangulation) [35]. Member checking, which involves giving participants the opportunity to confirm or deny the accuracy and interpretations of their data [36], was not performed with EMS clinician respondents – as questionnaire data were anonymous. Wherever possible throughout the duration of this investigation, researchers aimed to minimize areas where biases might occur, and where biases might cloud objectivity. As aforementioned, a form of triangulation referred to as investigator-triangulation was used to promote reflexivity trustworthiness in this investigation [35].

2.2. *Statistical analysis*

All statistical analyses were performed using IBM SPSS Statistics software (version 22; IBM, Armonk, NY, USA). Descriptive statistics (i.e., counts, frequencies) were used to report demographic information and clinical details of the sample population. As aforementioned, an inductive approach to conventional QCA was used to explore free-text response data from the purpose-built questionnaire..

3. Results

3.1. Participant characteristics

Participant characteristics are presented below in Table 1. Of the email invitations sent to 4500 EMS clinicians within Queensland Ambulance Service, $n = 326$ participants responded (response rate equal to 7.2%). Respondents spanned all age groups. Moreover, all Local Ambulance Service Networks (LASN) within Queensland were represented in the sample population. Note: In 2021 the QAS was restructured, changing from LASN to Regions with Sub-Districts. To a large extent, the geographical boundaries formerly defined by LASN still exist, and correspond most closely with "Districts". For the time period covered by this study, the term LASN was used and for this reason, will be used throughout this manuscript.

3.2. Previous burns experience

Experience with treating burns in the prehospital environment is summarized in Table 2. Just under two-thirds (62.9%) of EMS clinicians who responded to the questionnaire reported direct involvement in the treatment of acute burn patients in the prehospital setting within the last six months. Most participants reported some experience in treating adult and pediatric burn patients in the prehospital setting, and almost three quarters (73%) reported facing barriers when administering first aid to acute burn patients..

3.3. Barriers to the provision of burn first aid

3.3.1. Physical barriers

Physical barriers comprised two clear categories: *pain* and *medical barriers*. Pain was identified by EMS clinician participants as a significant barrier to administering optimal burn first aid in the prehospital setting. Respondents described pain as a barrier in two ways: non-compliance due to pain, and the need to administer pain relief before active cooling to settle the patient so first aid can be administered. Respondents also identified medical barriers to providing optimal burn first aid, which included subcategories such as lack of intravenous access, suspected inhalation injuries, large burn surface areas, and comorbid injuries mandating immediate transport.

> *"Pain – Active cooling is a priority in terms of first aid but for a patient, pain relief is the priority, and it can be difficult to prioritize cooling to a distressed patient." (Participant 98)*

3.3.2. Psychological barriers

Psychological barriers consisted of two categories: *emotional distress* and *mental health*. Emotional distress, encompassing both patient and parent/caregiver distress, was identified as a significant barrier. Non-compliance due to emotional distress and fear was identified as a separate and distinct barrier to first aid – despite having some overlap with the previous subgroup non-compliance due to pain. Parental distress resulting from guilt and trauma surrounding their child's burn was also reported as a barrier to first aid. Mental illness in this context referred to intentional injuries (self-harm and self-immolation, as well as intentional harm by another).

> *"…difficult scenes where family are extremely distressed and want immediate transport/removal from scene. Difficulty with non-accidental injuries in children and need to leave scene urgently." (Participant 22)*

Table 1 – Participant Characteristics.

Variable	N (%) $n = 326$
Sex	
Male	184 (56.4)
Female	141 (43.3)
Prefer not to answer	< 5
Age (Years)	
18 – 24	28 (8.6)
25 – 34	119 (36.5)
35 – 44	83 (25.5)
45 – 54	71 (21.8)
55 – 65	25 (7.7)
Highest Completed Education	
High school, diploma, or equivalent	28 (8.6)
Trade, technical, or vocational training	22 (6.7)
Associate's degree	15 (4.6)
Bachelor's degree	227 (69.6)
Postgraduate Degree	34 (10.4)
EMS Clinician Skill Level	
Student/Trainee	< 5
Graduate Advanced Care EMS Clinician	13 (4.0)
Advanced Care EMS Clinician	275 (84.4)
Critical Care EMS Clinician	36 (11.0)
EMS Clinician Work Experience (Years)	
< 1	16 (4.9)
2 – 4	75 (23.0)
5 – 7	37 (11.3)
8 – 10	46 (14.1)
11 – 13	47 (14.4)
14 – 16	27 (8.3)
17 – 19	15 (4.6)
20 +	63 (19.3)
EMS Clinician Work Region	
Metropolitan	198 (60.7)
Rural	113 (34.7)
Remote	15 (4.6)
Local Ambulance Service Networks (LASNs)	
Cairns and Hinterland	14 (4.3)
Central Queensland	23 (7.1)
Central West	< 5
Darling Downs	25 (7.7)
Gold Coast	40 (12.3)
Mackay	12 (3.7)
Metro North	62 (19.0)
Metro South	51 (15.6)
North West	< 5
South West	6 (1.8)
Sunshine Coast	20 (6.1)
Torres and Cape	< 5
Townsville	26 (8.0)
West Moreton	19 (5.8)
Wide Bay	19 (5.8)

Table 2 – EMS Clinician Experience Treating Burns in the Prehospital Setting.

Burns Experience	N (%) $n = 326$
Treated an adult burn patient	294 (90.2)
Treated a pediatric burn patient	270 (82.8)
Treated a burn in the last six months	
Yes	205 (62.9)
Faced barriers to the provision of first aid	
Yes	237 (72.7)

3.3.3. *Clinical barriers*

Clinical barriers were the third dimension identified and comprised of two main categories: *acute burn dressing issues* and *knowledge and training*. Clinical issues with acute burn dressings, such as application and adherence issues with plastic wrap, expired hydrogel burn dressing (HBD) stock, and residual gel left on burns following HBD usage, were all reported as barriers to the provision of optimal first aid. Seventeen percent of respondents reported clinical issues with the application of acute burn dressings. Knowledge and training, which encompassed subcategories such as lack of clear guidelines for the management of certain burn mechanisms (such as chemical burns), lack of knowledge on the importance of burn first aid, and lack of critical care EMS clinicians, were also reported as barriers to the provision of optimal first aid.

> *"…lack of knowledge of chemical interactions for management of chemical burns and lack of clear management pathway for chemical burns." (Participant 29)*

3.3.4. *Compliance barriers*

This dimension consisted of three overlapping categories, *patient behavior*, *pediatric patients*, and *communication*. Patient behavior as a barrier to administering first aid in this context referred to aggression, intoxication in adults, unwillingness to remove clothing in adults, and intellectual impairments. Two pediatric-specific barriers to first aid were identified. Fear and lack of understanding in pediatric patients can lead to poor cooperation with EMS clinician instructions – such as refusal to remain under CRW. Second, EMS clinicians described parents and caregivers of children with acute burn injuries often expected something *more* than 'just water cooling'. Respondents identified that remaining on-scene for 20-minutes to administer adequate cooling can give the appearance of postponing patient transport for definitive care. The last theme within this dimension was communication. Communication in this context referred to language barriers such as patients and families lacking proficiency in English, in addition to factors that prevent patients from communicating with EMS clinicians (most often resulting from severe pain and patient age).

> *"Pediatric patients under the age of 5 often don't understand why they are in so much pain and won't sit still for running water or allow you to apply dressings, which can make treatment difficult." (Participant 139)*

3.3.5. *Environmental barriers*

The final dimension consisted of three categories: *access to water, scene control,* and *time pressures*. Access to clean, cool, running water was identified as a barrier within the data. Scene control was identified as a separate and distinct barrier to first aid – despite having some overlap with the previous subgroup *patient behavior*. Scene control encompassed unsafe scenes, as well as controlling wind and outside temperatures. Time pressures were also reported as a barrier to first aid. Time pressure in this context referred to long anticipated transport times, bypass rules for major burns, distance from nearest burns center, unknown time of burn injury, and unknown cooling time prior to arrival on-scene..

> *"Lack of running water at the scene. I have worked out west in very rural and remote settings and the water that comes out of the tap is often brown and very hot, therefore at times I am unable to…adequately cool their burn with the facilities at hand." (Participant 293)*

3.4. *Facilitators to the provision of burn first aid*

3.4.1. *Fast & effective pain relief*

Fast and effective pain relief was the first dimension to emerge and comprised three categories: *rapid analgesia, simultaneous pain relief and cooling,* and *sedation*. Rapid analgesia was identified as the main facilitator to administering optimal first aid in the prehospital setting, with almost 64% of EMS clinicians who responded to the questionnaire reporting this facilitator. Simultaneous pain relief and cooling was reported as a facilitator to administering first aid – where patients are seated in a bathtub or shower with running tap water over the affected area and, during the cooling stage, EMS clinicians gain intravenous access and administer pain relief.

> *"The primary enabler that I have found is to have adequate analgesia on board prior to removal from the running water. Large burns will generally be moved to the shower early and I will gain IV [intravenous] access while the patient is in the shower to load them with a narcotic." (Participant 150)*

3.4.2. *Rapid cooling*

This dimension comprised of three categories: *immediate access to running water*, *access to equipment and resources*, and *cooling* en route. Immediate access to running water was identified by over half of respondents as a facilitator to providing adequate burn first aid. Access to equipment and resources in this context referred to well-stocked burns kits, access to home showers or taps, and access to clean water. The capacity to continue cooling en route to hospital was also described as a facilitator – most often in the context of life-threatening burn injuries where continued cooling on-scene is not appropriate.

3.4.3. *Patient compliance*

This dimension consisted of three overlapping categories: *following 0–0–0 instructions*, *patient cooperation,* and *bystander support*. Patients/bystanders/caregivers following 0–0–0 instructions as an enabler to the provision of optimal first aid in

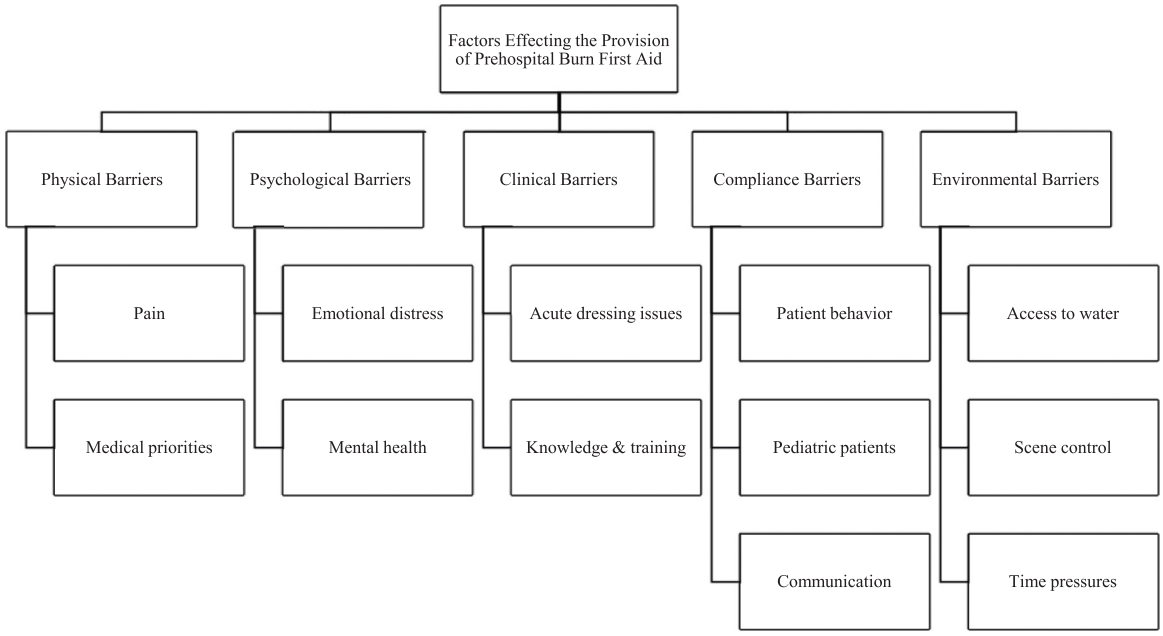

Fig. 2 – Barriers to the Provision of Prehospital Burn First Aid for EMS Clinicians].

this context referred to: patients knowing to call 0–0–0 (EMS telecommunications number in Australia), following 0–0–0 instructions, initiating water cooling on-scene before EMS clinician arrival, removal of clothing, and the removal of oneself from the burn source. Patient cooperation included compliance with EMS clinician instructions.

> *"Cooling first aid instructions provided by 0–0–0 phone operator prior to arrival on scene. If the burn has already been adequately cooled prior to our arrival, then we can go straight to pain management and dressings with transport to hospital" (Participant 153)*

3.4.4. *Patient support*

Patient support was identified as a facilitator to providing first aid. This dimension consisted of two categories, *reassurance* and *communication and rapport building*. Approximately one-fifth of Queensland EMS clinicians who responded to the questionnaire reported reassuring the patient as a facilitator to administering first aid in the prehospital setting. Communication encompassed explanation of the importance of running water first aid, building rapport with patients, and developing trust.

> *"Gaining patient confidence and trust in order to perform required cares. Respect of patients' privacy and dignity when removing clothing and performing cooling." (Participant 267)*

3.4.5. *Protective dressings*

Protective dressings were another dimension to emerge from the free-text data, and referred primarily to *the use of acute burn dressings* (such as plastic wrap and HBD) for two main reasons – pain relief and infection control. Acute burn dressings were reported to provide additional pain relief to patients during transport to definitive care – through evaporative cooling mechanisms with regards to HBD, and the prevention of air currents passing over exposed nerve endings in the dermis when using plastic wrap. Acute burn dressings also function as an aseptic technique – preventing wound contamination during transport.

3.4.6. *Knowledge & training*

This dimension consisted of three categories: *EMS clinician confidence, clear guidelines for management,* and *critical care EMS clinicians*. EMS clinician confidence included clinicians remaining calm when viewing and treating burns and exhibiting overall confidence throughout prehospital treatment. Clear guidelines for management in this context referred to familiarization with Queensland Ambulance Service Burns and Trauma Guidelines, having a simple approach to calculating burn surface area, and knowing hospital bypass rules for major burns. Having critical care EMS clinicians available was also identified as a facilitator to optimal first aid for the treatment of major burn cases, and where additional analgesics and advanced medical care is of benefit.

> *"Having a good knowledge of what to do to instils confidence in the patient, if the first aider also remains calm, this aids with keeping the patient calm too" (Participant 288)*

3.4.7. *Patient priorities*

This dimension encompassed three overlapping categories: *patient access, maintaining normothermia,* and *accurate burn assessment*. Patient access in this context referred to securing

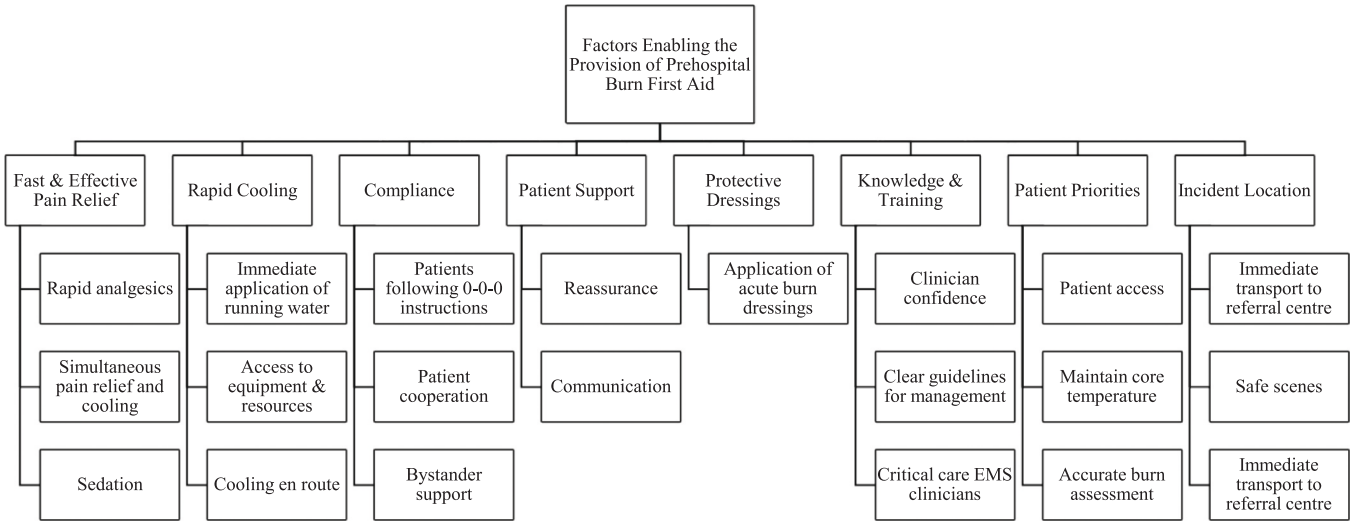

Fig. 3 – Factors Facilitating the Provision of Prehospital Burn First Aid for EMS Clinicians].

airways and gaining intravenous access for fluid resuscitation and pain relief – allowing prehospital services to remain on-scene for 20-minutes to administer CRW. Maintaining normothermia throughout the cooling process was also identified as a facilitator to the provision of optimal first aid. Accurate burn assessment was the last theme within this dimension and included precision in burn depth and size estimation, accurate assessment and primary survey, and rapid identification of life-threatening injuries superseding prehospital CRW (i.e., suspected inhalation burns).

3.4.8. *Incident location*

Incident location was the final dimension, and comprised of three categories: *immediate transport to appropriate facilities, safe scenes,* and *early prehospital notification*. Immediate transport to appropriate facilities encompassed subcategories such as non-remote locations, close proximities to major referral centers, short travel times, and the use of air medical services (Retrieval Services Queensland).

4. Discussion

The goal of this qualitative investigation was to explore and determine barriers and facilitators to the provision of adequate burn first aid by EMS clinicians in the prehospital environment. At present, not all burn patients are receiving optimal first aid of 20-minutes of CRW within three hours of the burn occurring [18–24]. We asked EMS clinicians in our investigation to provide information on barriers and facilitators of providing optimal first aid for patients with acute burn injuries on-scene. We found definite barriers faced by EMS clinicians in the prehospital setting, which can prevent burn patients from receiving optimal first aid on-scene. This research has identified some of these barriers, including difficult to control medical, clinical, and environmental factors. Past research into geographical remoteness and rates of burn first aid cooling identified that burn patients who sustained their injuries in far remote Australian regions were at an increased risk of not receiving 20 min CRW within 3 h [24]. A similar investigation examining patient and burn characteristics associated with inadequate rates of CRW first aid in pediatrics also found that optimal first aid varied as a function of geographical remoteness [19]. Results from this investigation align well with findings from previous studies. Lack of access to clean cool running water and long transport time pressures, often encountered in rural and remotes areas, were both reported as common barriers to prehospital first aid cooling for acute burn injuries.

In this investigation, pain was identified as the biggest barrier to the provision of optimal burn first aid in the prehospital setting. Moreover, fast and effective pain relief was identified as the main facilitator to administering optimal first aid to patients with acute burn injuries. Past research into prehospital pain management showed that adequate analgesia facilitated patient transport to hospital [37]. Moreover, pediatric pain management has previously been reported in the literature as a barrier to providing prehospital care [38,39]. Pain is a well-recognized and significant issue for patients with acute burn injuries [40–44] and results from this investigation align well with findings from past studies. The current investigation provides insight into how acute burn pain might prevent and hinder the provision of prehospital first aid.

EMS clinicians also identified clinical barriers resulting in transport to hospital being prioritized over remaining at the scene and administering 20-minutes CRW together with analgesia and acute burn dressings. These include the inability to establish intravenous access for fluid resuscitation or pain relief; the inability to gain airway access for patients with critical burns and suspected inhalation injuries; large burn surface areas; and hypothermia in large adult burns and in pediatric patients. These patients present difficulties in prioritizing primary care. Immediate transport to a tertiary hospital with a specialized burns center is often indicated over CRW first aid to halt the burn progression. For optimal

efficacy, burn first aid must be provided within three hours of the burn. Hence, where transport to hospital occurs within three hours of the incident, it is not necessarily inappropriate for transport to be prioritized over provision of CRW. In these cases, the referral center can assess if water-cooling is feasible after stabilization and hospital transport. Additional factors such as scene control, cooperation from others at the scene, and the challenge of managing parental distress for burned children and intoxication in adults can hinder the provision of first aid on scene.

Whilst some of the identified barriers to prehospital burn first aid cannot be controlled, such as incident location and the temperature/quality of tap water in remote and rural locations, we found potential for improvement in relation to other identified barriers. EMS clinicians have some influence over pain management for patients, as well as developing patient rapport and good communication skills. Factors identified as facilitators to the provision of on-scene burn first aid in this investigation (such as patient and caregiver support, reassurance, effective communication, and rapport building) have been reported in the broader literature. Findings from a recent qualitative investigation of barriers to providing prehospital patient centered care in critical pediatric events, also identified that emotional support and effective communication are significant facilitators to providing care in a prehospital environment [45]. For example, the authors concluded that providing an explanation of care to parents and caregivers of pediatric patients aided in the provision of prehospital care by EMS clinicians [45].

Solutions and strategies to further enhance provision of optimal burn first aid (defined as 20 min of CRW within 3 h post-burn) include targeted education and continuing professional development training for EMS clinicians. It is recommended that this education and professional development training focus on communication strategies, interpersonal skills, and patient rapport building that are specific to acute burn injuries and prehospital management, as well as integration of communication and emotional support techniques specific to burn injuries and management into prehospital burn protocols. Clinician confidence, as well as communicating the importance of CRW first aid for acute burn injuries, are critical to facilitate patient compliance with burn first aid instructions in the prehospital setting.

We also found a role for patient education to facilitate the provision of prehospital burn first aid. Improving public education about CRW, and routinely incorporating an explanation to patients and families about the benefits of CRW for acute burns and how it prevents burns from progressing to deeper injuries may improve patient compliance. Additional recommendations include public education campaigns and messaging to bring awareness to burn first aid practices and the use of 20 min CRW for acute burn injuries. A 2017 investigation conducted in Australia, which examined pediatric patient factors associated with poorer rates of burn first aid, also identified the need for improved public education on burn first aid cooling [19]. Such public education campaigns could address several of the barriers identified in this study.

4.1. *Limitations*

Limitations within this investigation merit consideration. This research provides a description of barriers and facilitators faced by EMS clinicians in one Australian state (Queensland) when delivering first aid to acute burn patients in the prehospital setting. The low response rate (7.2%) and self-reported nature of the data mean that bias cannot be ruled out (selection and measurement bias may be present). It is also important to note that the survey instrument used was customized for the purpose of this research. First aid case scenarios used within our questionnaire were adapted from a previous successful investigation, which examined burn first aid knowledge amongst Western Australian health care workers [29]. Our questionnaire was further tested and piloted by burns health care professionals prior to deployment, however we acknowledge the limitations associated with using an unvalidated instrument. Hence, identified themes within the data should be further explored by other prehospital EMS providers in Australia and internationally to replicate findings from this investigation. Nevertheless, practical implications of this research include assisting health care professionals to be better prepared for a range of barriers that might prevent first aid provision on-scene, and aid in the development of updated procedural protocols for the management of acute patients. Elucidated factors which help facilitate optimal first aid can also be incorporated into professional development training to help increase rates of burn first aid in the prehospital environment.

5. Conclusion

Our results suggest that, where patients do not receive optimal burn first aid on scene, it is not due to a lack of knowledge or awareness of prehospital clinical practice guidelines for acute burns, but the result of a number of clinical, patient, and environmental factors affecting prehospital first aid provision. This research provides a description of factors identified by EMS clinicians that can pose as barriers and facilitators to the administration of first aid (including CRW) in the prehospital setting. Five overarching dimensions were identified and integrated into a framework to describe barriers to the provision of first aid cooling on-scene: *physical barriers* (encompassing pain and medical priorities mandating immediate transport to a referral center over remaining on-scene for water cooling), as well as *psychological, clinical, compliance*, and *environmental barriers*.

EMS clinicians emphasized the importance of pain management for acute patients, and how adverse and uncontrolled pain can affect patient compliance with first aid instructions and cooling. Findings from this investigation function as an alert to prehospital health care providers regarding factors that can prevent, hinder, or facilitate, provision of best practice burn first aid for patients. Incorporation of the factors identified as facilitators in this investigation into EMS burn management protocols may further enhance rates of 20-minutes CRW provided in the prehospital setting. Results from this research also emphasize the need for ongoing professional development and education on acute burn

management for EMS clinicians, and the introduction of public health campaigns to increase public awareness of 20 min CRW for acute burns and the positive impact it has on burn wound progression and time to re-epithelialization.

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Author contributions

BRG, RMK, and MDH conceived the research and designed the study. BRG and RMK obtained research funding and supervised the conduct of the study. MDH undertook recruitment of participants, data management, and data analysis. KW provided statistical support and interpretation of results. MDH drafted the manuscript, and all authors contributed substantially to its revision. MDH takes responsibility for the paper as a whole. All authors have read and approved the final version of the article.

Declaration of competing interest

All authors who contributed to this original research manuscript declare no additional conflicts of interests. All authors declare no financial or other interests in the product (Burnaid®) or distributor of the product (Mundipharma). All authors declare no other past or existing relationships with the manufacturer or distributor of the product. Moreover, all authors declare no additional associations with the product manufacturer or distributor including consultancies, stock ownership, or other equity interests or patent-licensing arrangements.

Appendix

Appendix A. Online Survey.

1. What is your gender?
2. What is your age?
3. What is the highest degree or level of school you have completed? If currently enrolled, highest degree received?
4. What is your current employment rank within Queensland Ambulance Services?
5. How long have you been a paramedic?
6. Have you ever completed a first aid course?
   a) If YES, was burn first aid covered?
   b) If YES, was it within the last five years?
7. Have you been directly involved in the care of a person suffering a burn in the last six months?
8. Please select which classification best describes the region you work in:
9. Please select which Queensland Local Ambulance Service Network (LASN) you currently work as a paramedic:
10. An 18-month-old boy dressed in a t-shirt and nappy pulls a kettle of boiling water off the kitchen counter onto himself. He sustains 2% superficial partial thickness injuries to his left arm and chest. What first aid would you give?
11. A five-year-old girl is camping with her family when she trips and falls into an improperly extinguished campfire from the previous night. She was not wearing shoes and sustains 4% bilateral hand and feet burns which are pale and mottled in appearance. What first aid would you give?
12. A 32-year-old lady is wiping down her oven when some cleaning solution containing < 10% Sodium Hydroxide splashes onto her, causing a 1% chemical burn to her face and neck. What first aid would you give?
13. An 89-year-old man falls asleep in front of an electric heater and sustains 10% mixed thickness/intermediate burns to both lower legs, capillary return is present but delayed. What first aid would you give?
14. A 3-year-old girl spills a cup of instant noodles whilst eating at the table, she sustains 8% mixed depth burns to her abdomen, perineum, and upper thighs. Her mother attempted to cool with running water in the shower but reports her daughter became very distressed. What first aid would you give?
15. Have you ever transported an adult patient with an acute burn injury?
16. Have you ever transported a pediatric patient (aged 0 – 16 years) with an acute burn injury?
17. Have you ever applied plasticized polyvinylchloride film (plastic wrap/cling film) to a burn wound in the prehospital setting?
18. Have you ever applied Burnaid® hydrogel dressing to a burn wound in the prehospital setting?
19. Approximately, how many pediatric burn patients have you treated in the prehospital setting?
20. Approximately, how many adult burn patients have you treated in the prehospital setting?
21. What is your preferred acute burn dressing?
22. How confident do you feel managing a pediatric patient with a burn? (Adjectival scale: 1 not at all confident – 5 very confident)
23. How confident do you feel managing an adult patient with a burn? (Adjectival Scale: 1 not at all confident – 5 very confident)
24. How easy is plasticized polyvinylchloride film (plastic wrap/cling film) to apply to a burn wound? (Adjectival Scale: 1 very difficult – 5 very easy)
25. How easy is Burnaid® hydrogel dressing to apply to a burn wound? (Adjectival Scale: 1 very difficult – 5 easy)
26. How likely are you to use Burnaid® hydrogel dressing for the acute management of a burn injury in the future? (Adjectival Scale: 1 very unlikely – 5 very likely)
27. How likely are you to use plasticized polyvinylchloride film (plastic wrap/cling film) for the acute management of a burn injury in the future? (Adjectival scale: 1 very unlikely – 5 extremely likely)

28. If you have looked after a burn patient, have you experienced barriers to providing adequate first aid?
    a) If YES, what are the barriers?
29. If you have looked after a burn patient, what are key factors to enabling adequate first aid?

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