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Short Research Communications

Historical analysis of the economic cost of dengue in Australia

Deon V. Canyon

Anton Breinl Centre, James Cook University, Townsville Qld, Australia

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When human colonization of Australia took place by sea in the late 1780's, it unwittingly introduced a number of exotic invertebrate organisms. In modern times, traditional geographical barriers such as mountains, seas and deserts no longer limit pest population movement and global traffic has resulted in exotic insects becoming irretrievably established in foreign countries. The speed at which insect vectors and related diseases are emerging and re-emerging suggests that the development of less-developed countries is of primary importance. Vector-borne diseases are not just a health problem. They seriously hamper the development of less-developed nations by removing productive time from their populations and using up funds that could be better spent on development. This paper attempts to ascertain the economic cost of the invasion of Australia by a single mosquito species and the disease it vectors, dengue.

In Australia, *Aedes aegypti* (Diptera: Culicidae) is primarily responsible for the biological transmission of dengue which manifests in four serotypes capable of causing dengue fever, dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS). Cross-protective immunity lasts for about two months and immunity to a particular serotype is lifelong[1].

The rapid re-emergence and geographic spread of dengue is now common knowledge. The WHO estimates that every year, 100 million cases of dengue fever and 500,000 cases of dengue hemorrhagic fever occur with an average case fatality rate of 5%. Thus, 25 to 30 thousand fatalities are caused by DHF each year. In Puerto Rico, the disability-adjusted life years (DALYs) lost per million people increased from 1984–94 by 25% which placed the economic impact of dengue in the same order of magnitude as malaria, tuberculosis, hepatitis, STDs (excluding AIDS), the childhood cluster (polio, measles, pertussis, etc.), or the tropic cluster (Chagas, shistosomiasis, and filariasis)[2].

Since 1879, dengue has manifested itself in epidemic form in Australia. A general infection rate of 75% was proposed for all areas experiencing dengue up until the 1953–55 epidemic with infection rate since this date ranging from 2–38% depending on geographical area[3]. The mortality rate varies substantially. Typically, 1–7 DHF cases would result from 100 dengue fever cases and prior to the development of modern and adequate hospital management, 50% of DHF cases would die[1].

The earliest known dengue epidemics occurred from 1885–1901 and spread throughout most of Thursday Island, Townsville, Cairns, Cooktown, Pt. Douglas, Charters Towers, Normanton, Mackay, Ingham and Bowen with cases inland at Hughenden, Barcaldine, etc. This widespread epidemic penetrated into New South Wales in 1898 and at least three deaths were reported in Brisbane[4]. Based on an infection rate of 75% and a population of around 500,000 in 1900[5], 375,000 people were likely infected with dengue. Cases continued to a lesser degree until 1904–06, when the virus travelled north to infest Thursday Island, and south to Townsville where nine deaths occurred and down to Brisbane where a large outbreak caused 94 deaths. One death was also reported in Sydney. Thus, an estimated 190 DHF cases are likely with a maximum of 19,000 cases. However, if only 15% actually reported ill to a health clinic[3], a probable 126,730 people were infected in and around the Brisbane region. Interestingly, the population of Brisbane at this time was around 126,000[4]. Thus, the rate of one death to 1,000 possible cases seems plausible. From 1885–1923, 52 deaths were recorded in the Townsville region[6], which arose from around 52,000 probable infections. From 1916–19 and from 1924–26, New South Wales and Queensland were broadly struck with two epidemics which produced a similar infection rate. The number of infected people was estimated at around 600,000[4,6,7] in each of the two epidemics. From 1938–39, dengue was reintroduced and eventually caused another large epidemic in 1941–43. This epidemic swept from Queensland down to Brisbane with up to 85% infection rates in some towns[6,7]. In Townsville alone, 5000 cases were reported with 25,000 probable infections. Judging from past records and taking other areas into account, this figure could be doubled. This epidemic also swept north to Darwin and initiated the highly successful campaign to eliminate *Ae. aegypti* from Northern Territory. Dengue struck again in 1953–55 infecting 10–85% of the population with an estimated 15,000 cases[8]. During 1981–83 dengue returned to Queensland and was confirmed in 458 people. Using the recent notification rate of 15%[3], a possible 3100 people were infected in this epidemic. From 1991–2008, 4747 confirmed cases have been reported translating to a probable 32,000 infections.

Cumulatively, this leads to an estimated figure of 1,855,000 dengue infections in Australia since the introduction of *Ae. aegypti* and dengue, which is certain to be conservative due to a lack of information on numerous places that experienced epidemics. Based on this estimation, 1,819,340 people were infected prior to the 1980s with a 75% infection rate and 35,000 infections have resulted since the 1980s with an infection rate of 15%.

Meltzer *et al*[2] determined a figure of AU$80 per capita for the 1977 Puerto Rico epidemic, which included medical costs, control efforts, lost work and lost tourism[9]. If this figure is used to calculate the cost of all Australian dengue epidemics, the result is an all inclusive estimated total cost of 148 million dollars or 1.3 million dollars per annum.

The costs appear to be higher in Australia, which may be related to the population structure in North Queensland. The average time lost through illness in 1992–93 Charters Towers epidemic was calculated to be 10.5 days[10]. Using the total number of infected people, the result is 19,477,500 man-days being lost in total or 177,068 days per annum. With each day valued at AU$96, according to an average income of $35,000, the annual cost since the introduction of dengue is almost $17 million in current terms. However, epidemics are much smaller these days, infection rates have changed and the average wage has risen to $45,000, so it is only appropriate that the current situation should be separated from the past. Prior to 1990, the cost of work lost in today's dollars is close to two billion dollars. In the last 18 years alone, 32,000 infections with 336,000 lost days have equated to $41.3 million or $2.3 million per annum in lost time alone.

Judging from correspondence from several local city councils, labour costs for the control of exotic mosquitoes and related diseases range from $2,000–6,000 per year with brief major jumps during epidemics caused by reallocation of current staff to vector control operations. The cost of insecticides for exotic mosquito control is minimal during non-epidemic years, but ranges from a few thousand to nearly a million dollars per council per epidemic. The Charters Towers City Council determined the cost of vector control (insecticides and staff) for its 1992–93 epidemic to be $750,000 for a population of 8,500, resulting in a cost of $88 per capita. In a similarly sized epidemic, the Townsville City Council estimated direct costs in 2000 to be at least $500,000 for a population of 110,000 resulting in $5 per capita. Thus, it is problematic to use the per capita method in the modern environment where epidemics cause similar number of infections with similar costs regardless of the population size. The population in North Queensland is comparatively widely spread and small, and dengue-related expenses can be considerable even though large populations are not involved. The epidemic costs in Townsville and Cairns including annual maintenance costs averaged at least $200,000 per annum during the 1990s. When the Tropical Public Health Unit in Cairns dealt with a number of small epidemics lasting over three years from 1997–99, they formed a vector control unit called the Dengue Action Response Team (DART). In 2002, they guesstimated an annual cost of $200,000 equating to $2 per capita since the formation of this team. Thus, over the last decade, approximately 32,000 infections have occurred within an area containing a human population of not more than 300,000 at a control cost of around $400,000 per annum[11]. Interestingly, this same figure was quoted by Ritchie in McMichael *et al*[12] as the minimum amount spent per annum on dengue management in far North Queensland, but the source and derivation of the amount was not explained. This figure also did not include health or economic costs.

If all epidemics are taken into account, the cost of the introduction of *Ae. aegypti* to Australia, including lost work and control costs, has been considerable at around $17 million per annum. Since 1990, however, costs were more reasonable averaging out at around $2.7 million per annum. These figures do not include the intangible costs to individuals and society that can greatly detract from the quality of life and general wellbeing. Intangibles are perhaps similar in nature to environmental costs where quality is almost impossible to measure except in great leaps and bounds. Judging from the replies from City Councils in North Queensland and pesticide companies, control costs relating to non-exotic mosquitoes far exceed the costs due to exotic mosquitoes.

Since 2000, Australia has experienced a surge in viremic importations and dengue epidemics due largely to the construction of a new international airport in Cairns. The dengue fever: management plan for North Queensland 2005–10 renewed the government's commitment to lowering dengue incidence by reducing vector breeding through education programmes, encouraging greater awareness of the disease among general practitioners, improving physical and serological surveillance and mosquito control. However this has not been entirely successful. While Australia's medical entomologists argue that dengue is not endemic in Australia, the figures make this ever more difficult to justify.

References

1. Hayes EB, Gubler DJ. Dengue and dengue hemorrhagic fever. *Ped Infect Dis* 1992; *11:* 311–7.
2. Meltzer MI, Rigau-Pérez JG, Clark GG, Reiter P, Gubler DJ. Using disability-adjusted life years to assess the economic impact of dengue in Puerto Rico 1984–1994. *Am J Trop Med Hyg* 1998; *59:* 265–71.
3. Kay BH, Barker-Hudson P, Stallman ND, Wiemers MA, Marks EN, Holt PJ, Muscio M, Gorman BM. Dengue fever: reappearance in northern Queensland after 26 years. *Med J Austr* 1984; *140:* 264–8.
4. Cleland JB, Bradley B. Dengue fever in Australia. *J Hyg* 1918; *16:* 317–418.
5. Cameron D. Well nigh beneath contempt! Urbanisation and the development of manufacturing in Queensland, 1860–1930. Brisbane: Images of the Urban Conference Sunshine Coast University College, University of Queensland 1997.
6. Lumley GF, Taylor FH. *Dengue*. Sydney: University of Sydney & Commonwealth Department of Health,

Australasian Medical Publishing Company. *School Pub Health Trop Med* 1943; Ser Pub No. 3.

7. Walker AS, Meyers E, Woodhill AR, McCulloch RN. Dengue fever. *Med J Austr* 1942; *12:* 223–8.

8. Doherty RL. Clinical and epidemiological observations on dengue fever in Queensland, 1954–1955. *Med J Austr* 1957; *1:* 753–62.

9. Shepard DS, Halstead SB. Dengue (with notes on yellow fever and Japanese encephalitis). In: Jamison DT, editor. *Disease control priorities in developing countries*. New York: Oxford University Press Inc 1993; p. 303–20.

10. McBride WJH, Mullner H, Muller R, Labrooy J, Wronski I. Determinants of dengue 2 infection among residents of Charters Towers, Queensland, Australia. *Am J Epidemiol* 1998; *148:* 1111–6.

11. Canyon DV, Speare R, Naumann I, Winkel K. Environmental and economic costs of invertebrate invasions in Australia. In: Pimentel D, editor. *Biological invasions*. Boca Raton: CRC Press 2002; p. 45–66.

12. McMichael A, Woodruff R, Whetten P, Hennessy K, Nichols N, Hales S, Woodward A, Kjellstrom T. Human health and climate change in Oceania, a risk assessment 2002. Canberra: Commonwealth of Australia 2003.

Corresponding author: Dr Deon V Canyon, Disaster Health and Crisis Management Group, Anton Breinl Centre for Public Health and Tropical Medicine, James Cook University, Townsville Qld 4811, Australia.
E-mail: deoncanyon@gmail.com

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