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Impact of climate change on the health of Torres Strait Islander peoples living in the Torres Strait

Linda A Selvey, MBBS (Hon), BMedSci (Hon), MAppEpi, PhD, FAFPHM, of [redacted].

1. I am a public health physician with expertise in public health including the health impacts of climate change. I acknowledge that I have read the Harmonised Expert Witness Code of Conduct and the Federal Court of Australia Expert Evidence Practice Note and I agree to be bound by both the code and the practice note. My instructions for this report and the materials provided to me are annexed to this report.

2. My relevant qualifications are annexed in the form of a CV. My opinions in this report are based wholly or substantially on specialised knowledge arising from my training study or experience.

Annexure A	Linda Selvey Curriculum Vitae (March 2023)
Annexure B	Letter of Instruction to Linda Selvey

Table 1 List of Annexes to this report

Report Summary

3. Torres Strait Islander people living in the Torres Strait are already experiencing the impacts of climate change on their health and wellbeing and these impacts will increase with increasing global average surface temperatures. Climate change impacts on health directly through impacts such as increasing exposure to heat and extreme weather events such as storms, and indirectly through consequent impacts on human systems (for example culture, socioeconomic status, food availability and infrastructure), as well as ecosystems, and infectious diseases. In my opinion it is very likely that Torres Strait Islander people living in the Torres Strait are already experiencing increased morbidity and mortality from increasing heat exposure and that this will increase with increasing global average surface temperatures. Torres Strait Islander people living in the Torres Strait, particularly those living on low-lying islands, are already experiencing the impact of sea level rise and these impacts include mental health impacts. With increasing global average surface temperatures, other potential health impacts include reduced nutrition through increasing costs of healthy foods and decreased access to traditional foods, less fresh water availability and poorer water quality, increased rates of gastroenteritis and negative impacts on cultural and mental health and wellbeing. Torres Strait Islander people have poorer health than the broader Australian population and this means that they are more susceptible to the negative health impacts of heat. Torres Strait Islander people living in the Torres Strait are also more susceptible to the impacts of climate change on their health because of their location in a tropical area with temperatures and humidity already close to human physiological tolerance limits, limited access to health services compared to the broader Australian population, poorer housing and

limited resilience of infrastructure. Climate Change adaptation in the Torres Strait must be community-led and needs to include measures to increase the health status of Torres Strait Islander peoples, including improving nutrition, increasing physical activity and improving access to health services. Other adaptation measures include increasing access to housing appropriate for the hot climate, reducing overcrowding in housing and improving the resilience of infrastructure.

Linda Selvey – Qualifications, background and experience (see also Annexure A)

Q1. Please describe your academic qualifications and professional background, your experience in the field of climate change impacts on health (including, in particular, in the Torres Strait) and any other training, study or experience that is relevant to your answering the questions in this Annexure C. You may wish to do so by reference to a current curriculum vitae.

4. I, Linda Anne Selvey, MBBS(Hon), BMedSci(Distinction), MAppEpi, PhD, FAFPHM, am a public health physician and infectious diseases epidemiologist. I was appointed as Director of Communicable Diseases Branch at Queensland Health in December 1996, and appointed to the position of Executive Director, Population Health Queensland at Queensland Health in 2005. I have been an environmentalist all of my adult life, initially working towards the protection of the Wet Tropics rainforests through World Heritage status, and subsequently having a growing interest in climate change, particularly because of its impact on human health. In 2002 I wrote a report on the impacts of climate change and health on behalf of the Climate Action Network of Australia. This report, 'The Health Benefits of Mitigating Global Warming in Australia' was launched in 2002 by the then President of the Australian Medical Association Dr Kerryn Phelps when launching the AMA's position statement on climate change.

5. In 2001 I was appointed as Chair of the Queensland Conservation Council, a role that I continued until 2009. In 2007, I was trained by former US Vice-President Al Gore to deliver presentations about climate change. I delivered more than 20 presentations after that training. During that training I gained a much better understanding of climate science, and subsequent to the training I have increased my understanding through reading reports such as the IPCC reports. I left Queensland Health in 2009 to take on the role as CEO of Greenpeace Australia Pacific, a position I held for 2 years. I was then appointed as an Associate Professor in the School of Public Health at Curtin University in 2012, where I developed and delivered a course within their Master of Public Health (MPH) Program entitled 'Public Health Response to Climate Change'. This course included a background in climate science, climate change impacts on health, how to undertake a Vulnerability and Adaptation Assessment, and adaptation measures including disaster management. The course was an optional course in the MPH program but was well-attended and was evaluated highly by students. I was then appointed as an Associate Professor in the School of Public Health at The University of Queensland (UQ) in 2017, a position that I continue to hold. In this role I oversaw a review of all of the School's curricula with the goal of increasing the climate change content in our

courses and programs including with the Doctor of Medicine Program. I also deliver a number of lectures and workshops about climate change and health at UQ.

6. While at Curtin University I was elected as a member of the Council of the Australasian Faculty of Public Health Medicine within the Royal Australasian College of Physicians (RACP) and appointed to the role of Lead Fellow Climate Change. I was subsequently elected to the role of President of the Faculty and continued to work within the RACP in relation to climate change, including attending the UNFCCC COP 24 in Katowice on behalf of the RACP, where we advocated for increased attention to the health impacts of climate change in countries' Nationally Determined Contributions. I contributed to the development of three RACP position statements on climate change published in 2016 and am the RACP's representative on a multi-college body that produced the report 'Climate Change and Australia's Healthcare Systems. A review of literature, policy and practice' in 2022. I am currently the chair of the RACP Climate Change and Health Working Group.

7. As a public health physician and academic I have been well-trained in and have had extensive experience in evaluating the evidence in relation to public health. I have also worked in Aboriginal and Torres Strait Islander Health, at both policy and academic levels. While working at Curtin University and at UQ I have undertaken research into climate change and health. This includes some ongoing studies in relation to heat and health including adaptation. I have also undertaken related studies into mosquito borne diseases including in relation to rainfall patterns. I have listed the relevant publications, reports and research funding below.

8. In my roles at Queensland Health and as an academic at UQ, I have worked in the Torres Strait and/or with Torres Strait Islander people in relation to health issues affecting them. These include a number of infectious diseases (Japanese encephalitis, Dengue, the incursion of the mosquito vector *Aedes albopictus*, tuberculosis and HIV). I have also had a number of discussions with senior health staff working for the then Torres Strait and Peninsular Area Health Services District about broader health issues including chronic disease prevention. More recently I was a member of a research team that evaluated an intervention to improve water quality in the outer islands of the Torres Strait.

Relevant Publications and reports (for a full publication list since 2013 please see my CV in Annexure A)

(a) Strathearn, M., Osborne, N. J., & **Selvey, LA.** (2022). Impact of low-intensity heat events on mortality and morbidity in regions with hot, humid summers: a scoping literature review. *Int J Biometeorol.* 66(5), pp. 1013-1029. doi:10.1007/s00484-022-02243-z

(b) **Selvey LA,** Carpenter M, Lazarou M, Cullerton K. (2022). Communicating about Energy Policy in a Resource-Rich Jurisdiction during the Climate Crisis: Lessons from the People of Brisbane, Queensland, Australia. *Int J Environ Res Public Health,* 19(8),4635. doi: 10.3390/ijerph19084635

(c) Hall NL, Grodecki H, Jackson G, Go Sam C, Milligan B, Blake C, Veronese T, **Selvey L**. 2021. Drinking water delivery in the outer Torres Strait Islands: a case study addressing sustainable water issues in remote Indigenous communities. *Australian Journal of Water Resources*, 2021, 25(1): 80-89, doi: 10.1080/13241583.2021.1932280

(d) Davey, T. M., & **Selvey, L. A.** (2020). Relationship between Land Use/Land-Use Change and Human Health in Australia: A Scoping Study. *Int J Environ Res Public Health, 17*(23). doi:10.3390/ijerph17238992

(e) Arabena K, Armstrong F, Berry H, ... **Selvey L,** et al. Australian Health Professionals' statement on climate change and heath. *The Lancet*, 2018, 392(10160): 2169-70. DOI: https://doi.org/10.1016/S0140-6736(18)32610-2

(f) Walker LJ, **Selvey LA**, Jardine A, Johansen CA, Lindsay MDA, Mosquito and virus surveillance as a predictor of human Ross River virus infection in South-West Western Australia: How useful is it? *American Journal of Tropical Medicine and Hygiene,* 2018, 99(4):1066-73.

(g) **Selvey, LA**, Climate change is harmful to our health but taking action has many benefits. Med J Aust, 2015, 203(10), 398.e1. (Invited commentary)

(h) Selvey, LA, Johannsen, CA., Broom, AK, Antao, C., Lindsay, MD, Mackenzie, JS, Smith, DW, Rainfall and sentinel chicken seroconversions predict human cases of Murray Valley encephalitis in the north of Western Australia. *BMC Infectious Diseases,* 2014, 14:672 (10 December 2014)

(i) **Selvey, LA.,** Donnelly, J., Lindsay, M., PothumartuBodhu, S. Abrera, V. Smith, D.W. Ross River fever surveillance in WA – evaluation of surveillance system and implications for apparent changes in epidemiology *Commun Dis Intell* July 2014.

(j) **Selvey, L A**, Rutherford, S., Dodds, J., Dwyer, S., Robinson, S. The impact of climate-related extreme events on public health workforce and infrastructure – how can we be better prepared? *Australia and New Zealand Journal of Public Health.* 2014;38(3), 208-210.

(k) **Selvey LA**, Dailey L, Lindsay M, Armstrong P, Tobin S, Koehler AP, et al. The Changing Epidemiology of Murray Valley Encephalitis in Australia: The 2011 Outbreak and a Review of the Literature. *PLoS Neglected Tropical Diseases*. 2014;8(1):e2656.

(l) **Selvey LA**; Carey MG. Australia's dietary guidelines and the environmental impact of food "from paddock to plate". *Med J Aust,* 2013, 198, 18-9.

(m) Tong SJ, Mackenzie J, Pitman AJ, FitzGerald G, Nicholls, N, **Selvey, L.** Global climate change: time to mainstream health risks and their prevention on the medical research and policy agenda. *Internal Medicine Journal,* 2008, 38 (6a), 445-447.

(n) **Linda A Selvey** and John W Sheridan, *November 2002*. The Health Benefits of Mitigating Global Warming in Australia. *Available at:* http://www.cana.net.au

Health of Torres Strait Islander People

Q.2 Provide an overview of health and health-related data for Torres Strait Islanders. Without limiting the factors you consider relevant, include data on life expectancy, prevalence and incidence of disease, and factors that affect health outcomes of Torres Strait Islanders.

Life expectancy

9. There are limited data about the health of Torres Strait Islander people, beyond broader generalisations from data about the health of Aboriginal and Torres Strait Islander populations. The small numbers of Torres Strait Islander people living in the Torres Strait limits the ability to estimate life expectancy and other broad measures of health. Based on these generalisations, it is a widely accepted view that Torres Strait Islander people living in the Torres Strait have a shorter life expectancy compared to the broader Australian population.

10. While there has been improvement from estimates from the period 2010 – 2012, the life expectancy at birth for Aboriginal and Torres Strait Islander men was estimated for the period 2015 – 2017 to be 71.6 years, 8.6 years less than non-Indigenous men and for women, 75.6 years, 7.8 years less than their non-Indigenous counterparts. Except for people aged 85 years and over, the mortality rates for Aboriginal and Torres Strait Islander peoples are higher across all age groups compared to non-Indigenous Australians. The highest difference in mortality rates between Aboriginal and Torres Strait Islander men and their non-Indigenous counterparts occurred for 40 – 49 year olds (four times higher rate). The highest difference in mortality rates between Aboriginal and Torres Strait Islander women and their non-Indigenous counterparts occurred for 30 to 39 year olds (four times higher rate). The Torres Strait Islands are categorised as very remote. In the same study, the life expectancy for Aboriginal and Torres Strait Islander men in remote and very remote areas was estimated to be 65.9 years, 13.8 years less than their non-Indigenous counterparts living in remote and very remote areas. The life expectancy for Aboriginal and Torres Strait Islander women in remote and very remote areas was estimated to be 69.6 years, 14.0 years less than their non-Indigenous counterparts living in remote and very remote areas.[1]

11. In my opinion, based on the findings described in paragraph 10, Torres Strait Islander men and women living in the Torres Strait experience a significantly lower life expectancy than other Queenslanders. This is backed by data from the Australian

Census 2021, which found that the proportion of people living on the Torres Strait Islands who were aged 85 years and above was 0.2% compared to 2.1% of the Australian population; and the proportion of people living on the Torres Strait Islands aged 80 to 84 years was 0.6% compared to 2.2% of the Australian population.[2] The reduced life expectancy combined with higher birth rates compared to the Australian population means that Torres Strait Islander people living in the Torres Strait are a young population. The median age of people living in the Torres Strait is 27 years compared to the whole Queensland population where the median age is 38 years. Children aged 0 – 4 years are 10.9% of the population of the Torres Strait compared to 5.7% of the Queensland population. Conversely, 7% of the population of the Torres Strait is aged 65 years and above compared to 17% of the Queensland Population.[2]

Chronic disease

12. In the 2021 census, respondents were asked to report whether they had any chronic conditions (Table 2). I obtained these data by age group and calculated the rates of self-reported chronic conditions for people living in the Torres Strait and for the whole Australian population. I sourced these data from the Australian Bureau of Statistics.[a] People living in the Torres Strait (all people, the majority of whom are Torres Strait Islander people) reported higher rates of diabetes and kidney disease compared to the Australian population across all age groups. People living in the Torres Strait aged under 55 years reported higher rates of heart disease compared to the Australian population aged under 55 years. Those aged 55 years and over reported lower rates of heart disease compared to the Australian population. Children aged up to 15 years living in the Torres Strait reported slightly higher rates of chronic lung conditions compared to the Australian population, but the reported rates of chronic lung conditions were lower than the Australian population for people aged 15 years and over. The reported rates of asthma, cancer and dementia were lower among people living in the Torres Strait compared to the Australian population.

13. In my opinion there are limits to self-reported data. The responses to the questions depend on their interpretation, which can be affected by culture and language. A much lower proportion of people living in the Torres Strait (8%) exclusively speak English at home compared to 84.4% of Queenslanders as a whole.[2] While the majority of people living in the Torres Strait speak English, their interpretation of the census questions relating to chronic conditions may be different from the majority of Queenslanders. In my opinion qualitative research would be required to understand whether any questions about chronic health conditions were interpreted differently by people living in the Torres Strait compared to the broader Queensland population. Having said that, these data support the conclusion that Torres Strait Islander people living in the Torres Strait have higher rates of diabetes and kidney disease, and that they experience heart disease at a younger age than the Australian population.

[a] Obtained from: https://www.abs.gov.au/census/find-census-data/datapacks

Self-reported chronic condition	People living in the Torres Strait (rate/1000)	Australian population (rate/1000)	Ratio Torres/Australian rates
Diabetes			
0 – 14 yrs	2.24	1.58	1.42
15 – 54 yrs	56.30	21.38	2.63
55 + yrs	287.77	73.25	3.93
Kidney disease			
0 – 14 yrs	2.24	0.98	2.28
15 – 54 yrs	5.19	3.50	1.48
55+ yrs	40.77	24.41	1.67
Dementia			
15 – 54 yrs	0	0.33	0
55+ yrs	22.38	24.96	0.90
Heart disease			
0 – 14 yrs	6.72	1.74	3.87
15 – 54 yrs	24.7	8.74	2.82
55+ yrs	68.75	118.29	0.58
Asthma			
0 – 14 yrs	33.59	37.84	0.89
15 – 54 yrs	41.48	85.17	0.49
55+ yrs	67.65	85.71	0.79
Lung conditions			
0 – 14 yrs	1.34	1.24	1.08
15 – 54 yrs	0.74	4.52	0.16
55+ yrs	27.98	50.74	0.55
Cancer			
15 – 54 yrs	6.17	9.81	0.63
55+ yrs	23.98	80.75	0.30

Table 2. Rates of self-reported chronic conditions among people living in the Torres Strait and the Australian population by age group. 2021 Census data obtained from the Australian Bureau of Statistics.[b]

14. Queensland Health provided me with data on numbers of hospital admissions of Aboriginal and Torres Strait Islander people living in the Torres Strait for selected conditions regardless of where they were hospitalised. These data were provided for three financial years: 2019/2020, 2020/2021 and 2021/2022. They also provided data on hospitalisations for all Queenslanders in Queensland over the same time period. Using an average of these data over the three time periods and the 2021 census population estimates,[c] I calculated hospital admission rates for both populations. Because of small numbers the data were not provided for all age groups for Torres Strait Islander people, and for these conditions (pneumonia and influenza, chronic

[b] Obtained from: https://www.abs.gov.au/census/find-census-data/datapacks
[c] Obtained from: https://www.abs.gov.au/census/find-census-data/datapacks

obstructive pulmonary disease, stroke and asthma), the data are combined for all age groups. The results are shown in Table 3.

Hospital admissions for which condition	**Aboriginal and Torres Strait Islander people living in the Torres Strait per 1000 people**	**All Queenslanders per 1000 people**	**Ratio Torres Strait/All Queenslanders**
Coronary Heart Disease			
15 - 54 yrs	8	0.25	32.00
55+ yrs	55	0.63	87.30
Diabetes			
0 – 14 yrs	0	0.07	0
15 – 54 yrs	6	0.27	22.22
55+ yrs	30	0.39	76.92
Injury and poisoning			
0 – 14 yrs	33.73	2.53	13.33
15 – 54 yrs	49.88	3.33	14.98
55+ yrs	51.68	1.59	32.50
Pneumonia and influenza	6.00	0.34	17.65
Chronic Obstructive Pulmonary Disease	1.46	0.25	5.84
Stroke	2.67	0.13	20.54
Asthma	1.45	0.11	13.18

Table 3 Rate of hospital admissions for selected conditions averaged across three financial years (2019/2020, 2020/2021, 2021/2022) for Aboriginal and Torres Strait Islander people living in the Torres Strait and all Queenslanders. The hospital admissions were at any hospital in Queensland.

15. The rates of hospital admissions for Aboriginal and Torres Strait Islander people living in the Torres Strait across the three years for all reported conditions (coronary heart disease, diabetes, injury and poisoning, pneumonia and influenza, chronic obstructive pulmonary disease, stroke and asthma) were significantly higher than for Queenslanders as a whole.

16. The numbers do not count the number of individual people who had been admitted to hospital in a particular year, but rather they count the numbers of hospital admissions, regardless of the number of people who were admitted to hospital. One person could have been admitted to hospital for a particular condition more than once during a year. The small population of Aboriginal and Torres Strait Islander people living in the Torres Strait means that the absolute numbers of hospital admissions were small. In my opinion this could exaggerate the hospital admission rate if a small number of individuals required hospital admission an exceptional number of times over the time

period. The hospital admission rate for most chronic conditions reflects the prevalence of these conditions as well as (importantly) access to effective management of chronic conditions through outpatient services (usually in primary health care). If a patient with a chronic condition is well-managed outside of the hospital setting, they are less likely to require a hospital admission. These data reflect the findings of the census data described in paragraph 12 and table 2.

Burden of disease

17. The measure of burden of disease and injury is useful for assessing the need for health services and prevention strategies for particular populations.[3] The burden of disease is usually measured as Disability Adjusted Life Years (DALY), which is the sum of Years of Life Lost (YLL) and Years Lived with a Disability (YLD). The measures are affected by the incidence (new cases) of diseases, the age at which the disease occurs in a population, the impact of the disease on the people affected by it, and the death rate due to these diseases by age (YLL). Therefore if a population overall experiences the same incidence of disease as another population, but at a younger age, the population will experience higher years lived with a disability, and if fatal at an earlier age, will have a greater number of years of life lost.[3] In comparison to the hospital admission data described above, DALYs are calculated using estimates of incidence (new cases) rather than prevalence and are not affected by numbers of hospital admissions for a particular individual.

18. In 2017, on behalf of Queensland Health, Mitchell and colleagues published a report on the burden of disease and injury among Aboriginal and Torres Strait Islander people in Queensland and compared this to the burden of disease and injury of non-Indigenous Queenslanders.[3] This included calculations for Aboriginal and Torres Strait Islander peoples living in major cities, inner/outer regional areas and remote/very remote areas.[3] They then extrapolated their findings to estimate the burden of disease and injury for each Hospital and Health Service in Queensland.[4] Mitchell and colleagues calculated a ratio of the actual DALY estimates in each Hospital and Health Service compared to the expected if Aboriginal and Torres Strait Islander Queenslanders had the same burden of disease and injury as non-Indigenous Queenslanders. This is a measure of the relative burden of disease and injury experienced by Aboriginal and Torres Strait Islander Queenslanders.

19. The report found that Aboriginal and Torres Strait Islander people living in the Torres Strait-Northern Peninsula Area of the Torres and Cape Hospital and Health Service region (the area encompassing the Torres Strait Islands and the northern tip of Cape York) experienced 2.3 times the expected burden of disease and injury than non-Indigenous Queenslanders. There was an estimated gap of 14.8 years of health-adjusted life expectancy between Aboriginal and Torres Strait Islander people living in the Torres Strait-Northern Peninsula Area of the Torres and Cape Hospital and Health Service region and non-Indigenous Queenslanders. Health-adjusted life expectancy takes into account the prevalence of chronic conditions and premature death. The greatest contribution (two thirds) to the burden of disease and injury in this population were from the following broad causes: cardiovascular disease, diabetes, mental

disorders, chronic respiratory disease, cancers and unintentional injuries. Of these, the largest contributors were cardiovascular disease, diabetes and intentional injuries including self-harm and suicide.[4] The burden of cardiovascular disease among Aboriginal and Torres Strait Islander people living in the Torres Strait-Northern Peninsula Area of the Torres and Cape Hospital and Health Service region was 4.4 times; diabetes 6.8 times; chronic respiratory disease 2.6 times; cancer 1.5 times; and intentional injuries 7.7 times more than expected. Neonatal causes (including preterm births), and infectious and parasitic diseases were also important contributors to the health gap between Aboriginal and Torres Strait Islander people living in the Torres Strait-Northern Peninsula Area of the Torres and Cape Hospital and Health Service region and non-Indigenous Queenslanders. Neonatal causes are particularly important due to the much younger ages of those who are affected.[4]

20. It is worth emphasising that an important contributor (more than two thirds) to the large gap in burden of disease and injury between Aboriginal and Torres Strait Islander Queenslanders and their non-Indigenous counterparts is due to the earlier onset of and earlier mortality due to many chronic conditions (less than 50 years old), particularly cardiovascular disease and diabetes. This compares to the burden of disease and injury experienced by non-Indigenous Australians, among whom more than two thirds of the disease burden is experienced by people aged over 50 years. This age differential is highlighted by the finding that ischaemic heart disease is the leading cause of YLL among Aboriginal and Torres Strait Islander Queenslanders aged over 30 years, compared to non-Indigenous people, among whom ischaemic heart disease is the leading cause of YLL among those aged over 60 years.[3]

21. While the burden of disease and injury estimates for people living in the Torres Strait-Northern Peninsula area of the Torres and Cape Hospital and Health Service region were extrapolations of their broader study and were based on 2011 data,[4] their findings are largely consistent with Torres Strait Islander-specific data from the census and Queensland Health hospital admissions. Because of this, in my opinion the findings are likely to reflect the true burden of disease of Torres Strait Islander people living in the Torres Strait.

What are some of the factors influencing the inequities of burden of disease and injury among Torres Strait Islander peoples?

22. The inequities of the burden of disease and injury among Aboriginal and Torres Strait Islander peoples can be explained by inadequate access to culturally safe primary health care, specialist services and preventive services, inequitable access to life-saving procedures such as stents and coronary artery bypass surgery, intergenerational trauma, inadequate access to affordable healthy foods, crowded and inadequate housing, smoking and obesity, largely driven by socio-economic factors and the impacts of colonisation, including loss of self-determination and racism.[3, 5, 6] The 2017 Closing the Gap report attributed 53% of the gap in health outcomes between Aboriginal and Torres Strait Islander peoples and non-Indigenous Australians to socioeconomic determinants of health and 'risk factors' (health behaviours that are heavily influenced by the socioeconomic and environmental determinants of health).[7] Other authors have

attributed the remaining 47 percent to institutional racism in our health systems, interpersonal racism and intergenerational trauma.[8] These concepts are not considered controversial among public health practitioners and other health service providers, as reflected by the Royal Australasian College of Physicians' statements cited here.[5, 6] They are also acknowledged in the Torres and Cape Hospital and Health Services Health Equity Plan 2022 – 2025.[9] They are taught in Doctor of Medicine and Master of Public Health curricula at The University of Queensland and across other Australian universities.

23. The statements in paragraph 22 are broad and reflect the experiences of Aboriginal and Torres Strait Islander peoples as a whole and those living in the Torres and Cape Hospital and Health Services region. They are, however, reflected in the proceedings of The Torres Strait & Northern Peninsula Area Regional Healthy Communities Forum, 2023.[10] There were five themes in the forum: Structural (included "systemic racism" and "community control and sovereignty"); Services & programs (included "equitable access to safe and quality services"); Physical assets & finance (included "equitable financial investment"); Social Determinants (included "food security" and "social determinants of health"); and Cultural (included "culture at the core of health").

24. The ecological framework of health developed by Snijdjer and colleagues and cited in Christidis et al (pg 5)[11] is a useful illustration of the influences on the health of Aboriginal and Torres Strait Islander peoples. I have copied this framework below in Figure 1. Similar versions of this framework are used in teaching about the social determinants of health in a range of university health courses and are also used by the US Centers for Disease Control. They are applicable beyond Aboriginal and Torres Strait Islander health. The framework illustrates the different factors that influence the health of an individual, beyond the particular aspects of the individual themselves. Individual factors include health behaviours (such as diet, smoking and physical activity) and genetics. According to the Framework, the individual's relationships influence the health of an individual. As social beings, our behaviours are influenced by the behaviours of those around us. It is also well-recognised that strong and positive relationships can also be protective of health and wellbeing.[12] Individuals and their relationships are impacted upon by the community in which they live. The community level includes the broader community of people, as well as the assets within the community (such as parks, green space, access to healthy and affordable foods, access to health services, transport etc). The community is then influenced by the society and culture in which it is situated. This includes policies that may influence the assets in the community described above, as well as broader policies around taxation and welfare that can have large impacts on the individual.

25. As an example of the application of this framework to Aboriginal and Torres Strait Islander peoples' Health, Christidis and colleagues undertook a systematic review of the literature relating to the concerns and priorities of Aboriginal and Torres Strait Islander peoples about food and nutrition. Food and nutrition is important to the health of Torres Strait Islander peoples as they impact on high rates of obesity and diabetes in the population.[10] In the study by Christidis and colleagues, connection to culture was identified as a key contributor to health and well-being, and this included access to

traditional foods, and being able to pass cultural knowledge down to children and future generations.[11] This is important for Torres Strait Islander people living in the Torres Strait, whose unique cultures and languages (Ailan Kustom) are a key strength that needs to be supported and maintained through self-determination.[13] Societal factors identified by Christidis et al were "The anguish and shame of racism" (pg 6) and the easy available of junk food and the difficulty in accessing quality fresh food. At the community level, the authors identified the high cost of healthy foods relative to unhealthy foods, the importance of good housing and refrigeration for healthy eating and the important initiatives supporting healthy eating by Aboriginal and Torres Strait Islander organisations. At relationship level, the importance of healthy eating for the whole family was identified as a key theme, and at the individual level, having the knowledge and skills to cook simple healthy meals.[11]

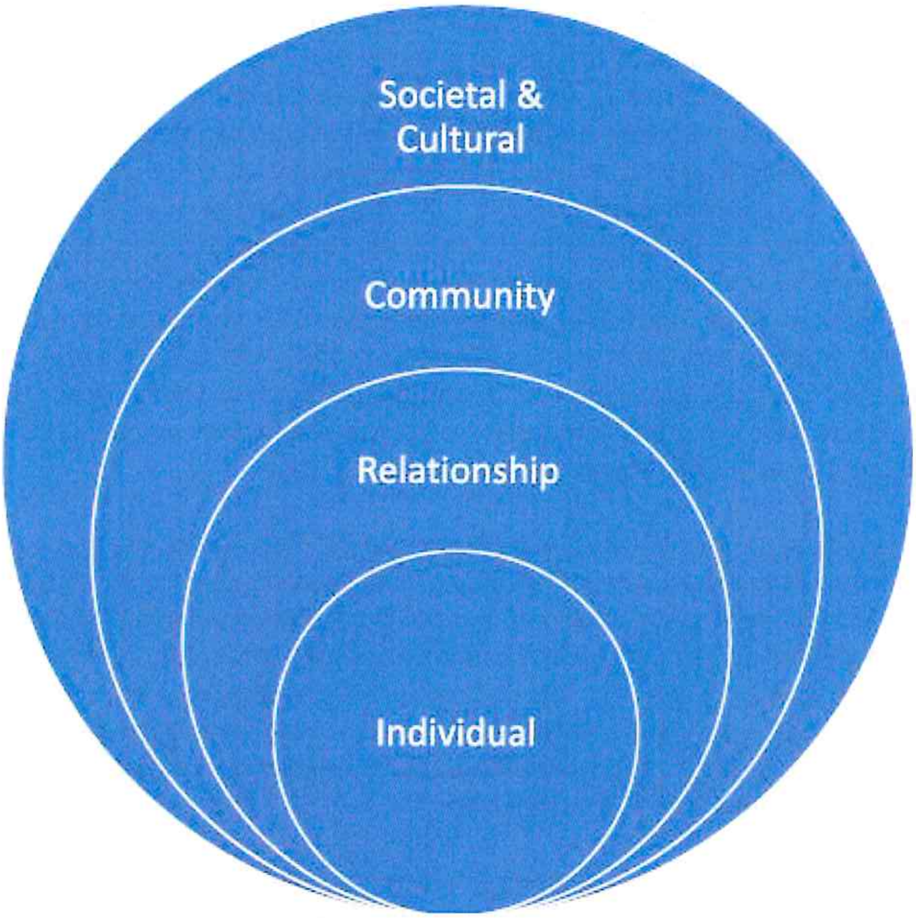

Figure 1. Ecological Framework, reproduced from Snijdjer et al in Christidis et al, 2021 pg 5[11]

26. A. Lee and colleagues assessed the cost of a healthy diet for a family of six people in the Torres Strait and the cost of the typical diet for Aboriginal and Torres Strait Islander peoples as found from the findings of the National Aboriginal and Torres Strait Islander Nutrition and Physical Activity Survey (NATSINPAS) 2012-2013. While Torres Strait Islander peoples were included in this survey, there were not sufficient numbers of Torres Strait Islander respondents in the survey to describe a typical diet of Torres Strait

Islander peoples living in the Torres Strait. The researchers assessed the cost of healthy food and the cost of a 'typical diet' for Aboriginal and Torres Strait Islander peoples (based on the NATSINPAS) in five communities across the Torres Strait Islands. They found that the cost of a 'typical diet' was higher than the cost of a healthy diet across all five communities, which is consistent with similar studies in Aboriginal remote communities. 'Discretionary foods' (foods that are not part of a healthy diet) were 64% of the total cost of the 'typical diet'. They found that the cost of both the 'typical diet' and the healthy diet was unaffordable (based on a definition of requiring more than 31% of income) and was 35% more than the cost of similar diets (both 'typical' and healthy) in the rest of Queensland. For a hypothetical family of six people in the Torres Strait, the study estimated that a healthy diet would cost 35% of the gross median income of the Torres Strait and 48% of the disposable income of people living on welfare. The cost of the 'typical diet' would cost 46% of the gross median income of the Torres Strait and 64% of the disposable income of people living on welfare. This is significantly higher than in the rest of Queensland. They also found that the cost of healthy diets in the Torres Strait would be 52% less affordable for people living on the gross median income of people living in the Torres Strait compared to people living on the gross median income of people living elsewhere in Queensland, and 30% less affordable for people living on welfare in the Torres Strait compared to those living on welfare in the rest of Queensland.[14] The authors conclude that this suggests major issues of food security in the Torres Strait, although they did not take into account access to traditional foods. They also conclude that their findings show that the cost of healthy foods is not the major barrier to a healthy diet in the Torres Strait. They attributed the high proportion of discretionary foods in the 'typical diet' to shelf placement, advertising and community preferences, as well as potential challenges with cooking and storing healthy food in the home.[14]

27. Francis Nona is a Badulaig man with strong ties to Saibai Island. He is a Lecturer in The University of Queensland School of Public Health, and he has travelled to many Torres Strait Islands. He was one of the authors of the study cited in paragraph 26.[14] [redacted] A Lee and colleagues did not describe the quality of the healthy foods in the five communities.[14]

28. The ecological framework described in paragraph 24 can also be applied to other determinants of health for Torres Strait Islander peoples living in the Torres Strait. For example, connections to spirts and ancestors, connection to country, land and sea, connection to culture, community and family are key determinants of wellbeing for Aboriginal and Torres Strait Islander peoples.[15]

Infectious diseases

29. The Torres Strait Islands' Northern location provides a favourable environment for a number of different mosquito species that do not occur in Southern Australia. The proximity of the outer Torres Strait Islands to Papua New Guinea and the strong cultural

and family ties between people living in adjacent areas increases the risk of exposure of Torres Strait Islanders to particular infectious diseases; primarily because of very poor living conditions and health services in neighbouring areas of Papua New Guinea.[16] The Torres Strait Protected Zone is an area that allows people movement between 14 Torres Strait Islands and a number of Papua New Guinea villages. The zone was created in 1978 when the Torres Strait Treaty was signed between Papua New Guinea and Australia. Because of poor living conditions across the Western Province of Papua New Guinea, people from non-treaty villages in Papua New Guinea are also known to travel to the Torres Strait for health care and other reasons.[16]

Mosquito-borne diseases – malaria, dengue and Japanese encephalitis

30. Malaria was eliminated in the Torres Strait in 1981. This means that since 1981 there has not been any ongoing transmission of the infection there. However, the main mosquito vector for malaria in the Torres strait, *Anopheles farauti* is abundant on Sabai Island, where brackish pools of water, mangrove swamps and flat coastal areas are ideal breeding grounds for the mosquito.[17] Small outbreaks of malaria have occurred on Saibai Island and occasionally on other islands including Erub and Dauan Islands. A relatively large outbreak of *Plasmodium falciparum* malaria occurred on Saibai and Dauan Islands in 2011. The infection was introduced to the Torres Strait Islands by an infected visitor from Papua New Guinea. The outbreak involved local transmission to eight and possibly a further three people on Saibai and Dauan Islands as well as cases detected around the same period among Papua New Guinean nationals who likely acquired their infection in Papua New Guinea.[17] While locally acquired malaria is uncommon in the Torres Strait and is not considered a large public health threat, four of the eight locally acquired cases in the 2011 outbreak required hospitalisation, reflecting the seriousness of the infection. In my opinion this outbreak highlights the importance of ongoing surveillance and prevention of malaria, particularly on Saibai Island because of the breeding sites for the mosquito vector. This includes adequate screening of houses, provision of and use of bed nets and ongoing mosquito control.

31. Dengue is a mosquito-borne flavivirus largely transmitted by two important mosquito vectors globally: *Aedes aegypti* and *Aedes albopictus*. *Aedes aegypti* is the more efficient mosquito vector of dengue, but *Aedes albopictus* is also important, particularly because it is a more aggressive mosquito and can tolerate cooler temperatures. Both mosquitoes can also transmit Zika and Chikungunya viruses, which have emerged internationally but have not become established in Australia.[18] Dengue can cause a range of unpleasant symptoms that typically last for about five days, although can last for longer periods. The most severe form, dengue haemorrhagic fever, can be fatal, and usually occurs after re-infection with another dengue virus type (there are four dengue types). Two Torres Strait residents died from dengue haemorrhagic fever in 2004.[18] Dengue only infects humans and there is insufficient population size and density in the Torres Strait and in North Queensland to sustain endemic dengue, but the infection is frequently introduced to Australia from overseas travellers or visitors from dengue-endemic countries (usually from Papua New Guinea in the case of the Torres Strait),[19] and if sufficient numbers of the dengue vectors are present, local outbreaks can occur. *Aedes aegypti* has been endemic in parts of the Torres Strait and the Australian

mainland for many years. *Aedes albopictus* was detected on 10 Torres Strait Islands for the first time in 2005. Because of concerns about the risk of introduction of *Aedes albopictus* to Southern Australia, significant attempts were made to eliminate the mosquitoes from the Torres Strait, but this was unsuccessful across most islands of the Torres Strait but largely successful on the inner islands. A mosquito survey undertaken in 2016 found that *Aedes aegypti* was found only on Thursday and Boigu Islands, and *Aedes albopictus* was found on all inhabited Torres Strait Islands except for Thursday, Boigu and Saibai Islands. The researchers undertaking the survey concluded that these findings were likely due to the aggressive *Aedes albopictus* mosquito displacing *Aedes aegypti.* [18] There were dengue outbreaks on Erub, Badu, Boigu and Masig Islands in 2016/17, with all but the outbreak on Boigu Island being likely transmitted by *Aedes albopictus*. The significance of the *Aedes albopictus* incursion onto a number of islands is that the mosquito control strategies for the two species are different,[18] and recent advances in dengue control using *Wolbachia* species that have resulted in virtual elimination of dengue transmission in North Queensland and elsewhere are not effective against *Aedes albopictus*.[20] The presence of *Aedes albopictus* also increases the risk of chikungunya, another mosquito-borne infection, an outbreak of which rapidly spread across Papua New Guinea in 2012.[19]

32. Japanese encephalitis is another mosquito-borne flavivirus that causes encephalitis in a small number of infected cases. The encephalitis can be fatal to humans and horses, and when not fatal can result in significant disability. The infection is endemic in Southeast Asia. A number of waterbird species are the natural host for the virus, which is amplified in domestic pigs to sufficient levels to enable viral transmission to humans via mosquitos.[21] Japanese encephalitis was noted to have occurred in Australia for the first time on Badu Island in 1995 when there were three symptomatic cases, of whom two died. A vaccination program commenced in December 1995 in the outer Torres Strait Islands and continues today. Other control strategies included moving domestic pigs to 2 km or more from human settlement and mosquito and sentinel pig surveillance. Two further cases occurred in 1998, one on Cape York Peninsula and the other was an unvaccinated child on Badu Island.[21] In 1998, surveillance identified widespread transmission of Japanese encephalitis among bird life in the Torres Strait. This was associated with a strong El Nino event that resulted in a severe drought in the Western Province of Papua New Guinea. It has been speculated that wetlands in the area dried up leaving stagnant pools that were ideal breeding grounds for the vector mosquito.[21] While there have been no clinical cases of Japanese encephalitis in the Torres Strait in recent years, the outbreaks are illustrative of the ongoing threat of incursions of infections to the Torres Strait.[19]

33. Tuberculosis (TB) is a major bacterial infection worldwide. It is a chronic infection that if it remains untreated is fatal and highly infectious to close contacts. TB control programs focus on case detection and treatment, something that is becoming increasingly challenging due to the emergence of *Mycobacterium tuberculosis* strains that are resistant to a range of drugs used to treat the infection.[19] In Australia, most TB cases occur in people who acquired the infection in endemic countries overseas. TB is poorly controlled in Papua New Guinea and there are many emergent strains of multi-drug resistance *M. tuberculosis* in the country, including in areas adjacent to the Torres

Strait. Some of these cases attend Queensland Health facilities for their TB treatment, and generally health centre staff in the outer islands are familiar with TB detection and treatment.[19] TB transmission to Torres Strait Islander people does occur, where the incidence is nearly 200 times higher than in the non-Indigenous Australian-born population.[19] This includes transmission of drug-resistant strains of *M. tuberculosis*, which is of particular public health importance due to more limited treatment options.[16]

34. [redacted] Data from the Queensland Health notifiable conditions reporting system[d] are only available at the level of the Torres and Cape Hospital and Health Services with an overall population of 26,365 people. Therefore, it is difficult to know whether the incidence of a number of infectious diseases in the Torres Strait Islands is the same as for the rest of the Hospital and Health Services area.

35. Having said that it is worthy of note that the rate of notified non-typhoid Salmonella cases in 2022 was 2.2 times higher in the Torres and Cape Hospital and Health Services area than in Queensland as a whole. Non-typhoid Salmonella infections are a common gastrointestinal infection in Australia and worldwide. In Australia the majority of cases (around 70%) are thought to be transmitted via food.[22] The organism can multiply in food, and therefore cases tend to be more common in warmer climates, particularly where there is less access to refrigeration.[23, 24] The notification rate of Campylobacter infections in 2022 on the other hand was lower in the Torres and Cape Hospital and Health Services area than in Queensland as a whole. Diagnosis of both Salmonella and Campylobacter infections requires analysis of stool specimens and in my opinion these may be less common among people with diarrhoeal disease in the Torres and Cape Hospital and Health Services area than in urban areas of Queensland due to less access to health services.

36. The rate of notified cases of invasive Group A streptococcal infections in 2022 was 8.8 times higher in the Torres and Cape Hospital and Health Services area than in Queensland as a whole. This is notable because Group A streptococcal infections result in Acute Rheumatic Fever and consequent Rhematic Heart Disease in some untreated cases. Rheumatic fever was once common in Australia and throughout the world but has largely been eliminated in high-income countries due to improved living conditions and use of antibiotics. Rheumatic fever in Australia is more common among Aboriginal and Torres Strait Islander people, particularly those living in remote areas as a result of crowded housing and insufficient access to primary health care.[25] Rheumatic Heart Disease is an important cause of heart failure and premature death among Aboriginal and Torres Strait Islander peoples.[25] In 2022, the notification rates of acute rheumatic fever was 63.1 times and of new cases of rheumatic heart disease was 26.7 times in the Torres and Cape Hospital and Health Services area than in Queensland as a whole.

[d] https://www.health.qld.gov.au/clinical-practice/guidelines-procedures/diseases-infection/surveillance/reports/notifiable/annual

37. The reasons behind higher rates of particular infections in among Torres Strait Islander peoples living in the Torres Strait include geographical location (proximity to Papua New Guinea and West Papua), tropical climate, overcrowded housing,[2] and compromised water quality,[26] sanitation and hygiene.[27]

Perinatal conditions

38. According to a report by the Australian Institute of Health and Welfare, pre-term birth, low birth weight and still births are important perinatal conditions that occur more often among Aboriginal and Torres Strait Islander peoples than in the broader Australian population, particularly in remote and very remote areas.[28] Maternal smoking, maternal obesity and lower access to antenatal care are some of the reasons for these differences. Fortunately there has been an improvement in perinatal statistics for Aboriginal and Torres Strait Islander peoples between 2008 and 2018[28] Pre-term birth and low birth weight can result in poorer health outcomes in later life.[29] I could not find any specific data in relation to perinatal conditions among Torres Strait Islander women and babies. However, the Torres and Cape Hospital and Health Services Health Equity Strategy (2022 – 2025) notes that 11% of Aboriginal and Torres Strait Islander babies born in the Torres and Cape Hospital and Health Services region have high birth weight compared to 8.9% of Aboriginal and Torres Strait Islander babies born elsewhere in Queensland.[9] Being born with a high birth weight also can have long-term implications for the infant (particularly childhood obesity),[30] and is most commonly a result of maternal diabetes (including gestational diabetes) that is uncontrolled during pregnancy or maternal obesity.[31]

39. It is not possible to categorically state that pre-term birth, low and high birth weight and still births occur more often among Torres Strait Islander people living in the Torres Strait compared to the broader Australian population. However, the factors leading to these conditions (~~maternal~~ smoking, ~~maternal~~ obesity and lower access to antenatal care) are more common among Torres Strait Islander people living in the Torres Strait.[10] Therefore, in my opinion it is likely that pre-term birth, low and high birth weight and still births occur more often among Torres Strait Islander peoples living in the Torres Strait.

Effects of climate change on the health of Torres Strait Islanders living in the Torres Strait

Q3. What, if any, are the current and future effects on the health of Torres Strait Islanders arising from the Torres Strait Impacts?

In your answer, please identify and describe any current and likely future: direct impacts on the human body; and indirect impacts on the human health of Torres Strait Islanders that arise from the Torres Strait Impacts.

In answering this question, state whether the nature, extent or likelihood of those impacts differs as global average surface temperature increases.

40. **Climate change affects human health directly through increasing the frequency and severity of climate-related extreme events, such as heatwaves, injuries/drownings from storms and floods. Climate change also affects human health more indirectly through impacts on human and ecological systems. For example, climate change can impact on the availability and quality of fresh water, the cost and availability of healthy food, the availability of important infrastructure such as housing and wastewater, the ability to practice culture, and the incidence of infectious diseases.[32] These impacts are already being experienced in Australia and elsewhere and are likely to increase with further increases in global average temperature.[33] In this report I will cover the major direct and indirect health impacts that in my opinion are most pertinent to Torres Strait Islander people living in the Torres Strait.**

Direct Health impacts – increasing heat exposure

41. **Of all climate-related extreme events in Australia, heat is the leading cause of morbidity and mortality.[33] For this report I assume that global average surface temperatures are now 1.2°C above pre-industrial levels and that the global average surface temperatures will continue to increase. I also assume that there is a causal relationship between these increases and increased average surface temperature, increased humidity and wet-bulb temperatures and increasing heatwaves in the Torres Strait.**

42. **There have not been any specific studies investigating the impact of extreme heat on the health of people living in the Torres Strait or on other populations living on small islands. Small population numbers mean that such a study would not be viable. Many studies conducted around the world have found an association between heat exposure and increased morbidity (illness) and mortality (death).[34] Based on this, in my opinion it is reasonable to assume that heat will have already impacted on the health of Torres Strait Islander people and this will increase over time as global average temperatures increase. Many tropical areas, particularly those near the ocean, tend to have fewer heat extremes, but temperatures in these areas, particularly in combination with humidity and warm nights, mean that there is little margin for adaptation to higher temperatures.[35] A study by T. Longden investigated the impact of heat on mortality across Australia (including the Torres Strait) using mortality data from 2006 to 2017. He found that in places with hot humid summers (tropical regions) both extreme heat and high temperatures that were not extreme were associated with increased mortality. He**

also found that the overall number of deaths on hot days that were not extreme was higher than on days of extreme heat.[36] This is because, while there was a higher risk of death on extremely hot days than on non-extreme hot days, there were overall many more days of exposure to heat on non-extreme hot days.[36]

43. I obtained daily maximum and minimum temperature data recorded on Horn Island, Torres Strait from the Bureau of Meteorology[e] from 2001 to 2022. I calculated the daily mean temperature (the average between the maximum and minimum temperatures) for each day that the temperature data were available. The daily mean temperature reflects the overnight temperature as well as the hottest temperature in the day. Overnight temperatures are important for health, as high overnight temperatures do not allow recovery from heat, houses to cool down and can impede quality sleep. Some studies have found that high overnight temperatures are also associated with increased mortality, for example see the paper by C. He et al.[37] Across the 22 years from 2001 to 2022, the highest daily mean temperature recorded in the year ranged from 30.3°C in 2006 to 32.35°C in 2002. The number of days with daily mean temperatures higher than 28°C ranged from 97 in 2006 (in 2006 there were 13 days with missing temperature data) to 242 in 2016 (in 2016 there were no days with missing temperature data).

44. Exposure to high temperatures can directly impact on health by causing heat exhaustion and heat stroke. Heat stroke, when the body's core temperature reaches dangerously high levels, is a health emergency and can be fatal. The body's attempts to cool itself also stresses peoples' heart, lungs, and through dehydration from sweating, kidneys. Therefore morbidity and mortality due to heat can present as exacerbations of cardiovascular, respiratory or kidney disease.[38] Exposure to heat has also been known to cause deaths and illness due to exacerbation of diabetes as well as pre-term births.[34] Young children and older people are most vulnerable to the impacts of heat, as are people on some medications, particularly diuretics and some psychiatric drugs. However, all age groups are susceptible to the health impacts of heat. Human behaviour also affects susceptibility to heat, and outdoor workers and people working in hot places are susceptible because of increased heat exposure. Wearing appropriate clothing, drinking plenty of fluids and staying in cool places are ways to reduce heat impacts on health. It is possible to acclimatise to heat through heat exposure, and through behavioural and environmental measures such as choice of clothing, seeking shade, drinking water, housing design and planting trees.[38] However there are physiological limits to the human capacity to acclimatise to heat exposure, particularly during physical activity,[38, 39] resulting in limits to capacity for outdoor work and recreational physical activity in the heat. As physical activity is essential for good health, increasing ambient temperatures can mean reductions in physical activity and consequent increases in metabolic conditions such as diabetes and cardiovascular disease.[35]

45. Scientists have attempted to estimate the physiological adaptability temperature limit for humans based on human capacity to maintain core body temperatures at a level suitable for human function (36.8 +/- 0.5°C).[38, 40, 41] The theoretical estimation of this

[e] http://www.bom.gov.au/climate/data/

temperature limit was a wet-bulb temperature of 35°C.[41] The wet-bulb temperature is the temperature reading when the thermometer bulb is wrapped in a wet cloth. The temperature is therefore measured as a combination of heat and humidity (as the thermometer bulb cools as a result of evaporation of some of the water in the cloth). Higher temperatures with low humidity will have a lower wet-bulb temperature than the temperature measured with a normal thermometer, but as humidity increases, the ambient temperature more closely aligns with the wet-bulb temperature. Wet-bulb temperatures can be estimated by calculation when ambient temperature and humidity is known.[f] To date, a wet-bulb temperature of 35°C has not been observed on earth, but increasing temperatures in the Middle East are getting close and are likely to be exceeded by 2100.[41] While a wet-bulb temperature is the theoretical limit of human tolerance to heat, Vecellio and colleagues in a study conducted in a temperature-controlled chamber found that the core body temperature of healthy young adults doing low levels of physical activity (described as the level of physical activity required for daily living) started increasing to the point where the ambient temperature was not tolerated at lower wet-bulb temperatures than 35°C. In humid heat, the tolerable wet bulb temperature was between 30 and 31°C, and at low humidity but with high temperatures (50°C), the tolerable wet-bulb temperature was as low as ~~26~~ 25°C.[41] Based on what is known about the pre-dispositions to the impact of heat on health described in paragraph 44, and because the subjects were young healthy people, in my opinion it is likely that the tolerable wet bulb temperature would be lower for older people, people with chronic diseases and young children.

46. The temperature at which heat impacts on morbidity and mortality at a population level varies according to the geographical location and other weather parameters such as wind speed, humidity, radiant temperature (heating from surrounding surfaces such as roads and buildings) and overnight temperature.[34] In general, people living in tropical regions are more likely than in temperate regions to live in houses that are appropriate for high temperatures, and to be physiologically adapted to heat. However, this is not the case on all islands in the Torres Strait. [redacted]. According to the Index of Relative Socioeconomic disadvantage in 2016, the population of the Torres Strait is classified in the lowest quintile of socioeconomic disadvantage in Australia.[42] In his study, T Longden found that, relative to the minimum mortality temperature[g], the mortality on hot and extremely hot days was higher in areas of Australia where the population is in the first quintile (the lowest) of socioeconomic status compared to other areas of Australia. Longden concludes that this is likely to be due to insufficient adaptation to heat (such as cooler houses, fans and air-conditioning) in areas with the lowest socio-economic disadvantage because of this disadvantage.[36] The Torres Strait Islands are classified as being in the lowest quintile of socioeconomic disadvantage.[42]

[f] https://www.omnicalculator.com/physics/wet-bulb
[g] The temperature at which the death rate in a population was the lowest

47. Given the lack of literature in relation to the impacts of heat on Torres Strait Islanders living in the Torres Strait, I have reviewed the literature on the impact of heat on morbidity and mortality in tropical regions with hot, humid summers, with the aim of extrapolating these findings to the impact of heat on Torres Strait Islander peoples living in the Torres Strait. I chose these papers because of the potential similarities in climate between the Torres Strait and the places where these studies were conducted. In making conclusions about the impacts of heat on morbidity and mortality in the Torres Strait from the findings among populations in tropical areas, I assumed that the populations will have acclimatised to the heat more than in areas with less hot temperatures, and that they will have also been exposed to humidity when it is hot. However, across these studies there will be differences in local climates, including the maximum temperatures experienced and in access to houses with good solar design, ventilation and air-conditioning. There will also be differences between the different studies reviewed below and the Torres Strait (some more than others).

Heat-related Morbidity (illness)

48. There are few studies that investigated the impact of heat on morbidity in tropical areas.[43] Overall, heat has been associated with increased hospital admissions for a range of conditions including in the perinatal period as well as an increase in pre-term births.[44-49] The risk of hospitalisation increases with increasing severity of heat and heatwaves. Children 0 – 9 years and people aged 70 and over are more likely to be hospitalised.[45-48]

49. A large study by Q Zhao et al investigated the impact of heatwaves on hospitalisation in 1814 cities across all regions in Brazil in the five hottest months of the year during 2000 – 2015. The study found that the greatest impact of heat on hospital admissions was due to perinatal conditions, but there were also increased hospital admissions for a range of other conditions (endocrine/nutritional/metabolic – including diabetes; skin conditions; genitourinary – including kidney disease; respiratory, injury and poisoning; maternal conditions; and for more extreme heatwaves, neoplasms – cancer). The study did not find an increase in hospitalisations due to cardiovascular disease, and the authors concluded that this was most likely due to increased mortality due to cardiovascular disease, that occurred before the patient could reach hospital.[45] Only the North, Northeast and Central West regions of Brazil have a tropical climate. The study found an association between heatwaves and hospitalisation in the Northeast and Central West regions of Brazil but not the North region. The authors concluded that because the North region of Brazil was the hottest part of the country, people living in the North region of Brazil were less susceptible to the impacts of heat because they had adapted to heat. However, the North region of Brazil is the least developed with less access to primary health care.[50] Another possible explanation may be that limited access to hospitals (as described by TA Rocha and colleagues)[51] was a reason for not observing an increase in hospitalisations during heatwaves in the North Region.

50. The study by Zhao and colleagues described in paragraph 49 was noteworthy because their study included over 58 million hospitalisations, which allowed them to study the impacts of heatwave at the level of particular conditions and in different geographical

areas across Brazil. They did, however, investigate hospitalisations in cities, which, in my opinion is likely to reflect where the hospitals were located. As there are no cities in the Torres Strait, these findings are not directly comparable. The mean daily mean temperature over the study period was 27.1 ± 0.7°C[h] in the North region; 26.0 ± 1.6°C in the Northeast region; and 25.0 ± 1.3°C in the Central West region. These temperatures were consistent with the observed temperatures on Horn Island in the Torres Strait where the mean daily mean temperature across all months from 2001 to 2022 was 27.7 ± 1.3°C (see paragraph 43).

51. D Phung and colleagues investigated the impact of high temperatures on hospital admissions for cardiovascular disease in the two largest hospitals in Ho Chi Minh City in South Vietnam from February 2004 to December 2013. The average daily mean temperature in Ho Chi Minh City was 28.2 ± 1.4°C, which is comparable to Horn Island in the Torres Strait (paragraph 50). They found that cardiovascular hospital admissions increased sharply when the daily mean temperature was above 30°C and that the risk increased with increasing temperature.[46] Another study by D Phung and colleagues investigated the impact of high temperatures on hospital admissions in 13 provinces in the Mekong Delta Region of Vietnam from January 2002 to December 2014. The mean of the daily mean temperatures in the provinces ranged from 26.4°C to 27.8°C. They calculated the increased risk of hospitalisation for each province for days when the mean temperature was 21°C or above. This increased risk varied from ~~0.4 to 3.6~~ 0.5 to 3.5 for every 1°C above 21. The increase was highest for people aged 75 years or above, and for admissions due to infectious causes. Population density, and higher rates of both poverty and illiteracy in provinces were correlated with higher levels of increased risk of hospital admissions. Conversely, higher rates of safe water and sanitation and a higher proportion of rural populations in provinces were correlated with decreased levels of increased risk of hospital admissions.[52] In another study conducted across 14 provinces in Vietnam, increasing temperatures in the warm season was associated with increased hospitalisations for kidney disease. The association was strongest for exacerbations of chronic kidney disease and for urolithiasis (kidney stones and stones in the ureters). The mean of the daily mean temperature across all 14 provinces in the study period (2003 – 2015) was 27.7 ± 2.2°C,[~~52~~ 47] which is similar to Horn Island in the Torres Strait from 2001 to 2022 (paragraph 50).

52. While the studies in Vietnam recorded similar temperature ranges to the Torres Strait, there are notable differences between Vietnam and the Torres Strait, particularly in relation to population density, living standards and culture. Therefore findings of the studies described in paragraph 51 cannot be directly extrapolated to the Torres Strait.

53. A study undertaken by J. Goldie et al investigated the impact of heat and humidity on hospital admissions in Darwin, Australia from 1993 to 2011. They found a statistically significant increase in hospital admissions of ~~1.78~~ 1.74% (*P*=0.049)[i] for every 2°C increase in

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[h] The number after the ± symbol is the standard deviation of the mean, a measure of the variability of the data

[i] The *P* value is a measure of the statistical significance of an association between two variables. A *P* value of less than 0.05 is generally considered to be statistically significant. A *P* value of 0.05 means that there is a 5% probability that the observed association is due to chance. A *P* value of 0.001 means that there is a 0.1% probability that the observed association is due to chance.

maximum temperature and a significant increase in hospital admissions of ~~3.74%~~ 3.73 ($P<0.001$) for every 10 percentage point increase in the daily maximum relative humidity. These increases were independent of each other (that is there was no interaction between the impact of humidity and the impact of high temperatures).[48]

54. While none of the studies described in paragraphs 48 to 53 can directly be extrapolated to the Torres Strait, the consistency in association between high temperatures and hospital admissions in the above studies in areas with similar climate to the Torres Strait is noteworthy. On that basis it is my opinion that it is likely that Torres Strait Islander people living in the Torres Strait are already experiencing increases in morbidity (particularly exacerbations of existing respiratory and kidney diseases and diabetes), and increased pre-term births due to the impacts of increasing heat. Given that increases in morbidity are associated with increasing temperatures, in my opinion it is likely that further increases in global average surface temperatures will increase heat-related morbidity among Torres Strait Islander people living in the Torres Strait.

Heat-related mortality

55. I searched the literature for papers describing the impact of heat or temperature on mortality in tropical areas that had wet summers/warm season. My search parameters were similar to a study I undertook in 2020. This study was investigating the impacts of low intensity heat in places with hot humid summers, and it included areas with sub-tropical as well as tropical climates.[43] For the purpose of my literature search for this report, I restricted my search to papers describing the impact of heat in tropical areas and for all heat intensities. The final search string that I used was: (morbidity OR 'hospital admissions' OR 'hospital presentations' OR mortality) AND (heatwave OR 'heat index' OR 'excess heat factor' OR humidex OR 'extreme heat' OR 'warm spells' OR humidity [MeSH Terms] OR humidity OR 'Extreme Heat' [MeSH] OR 'daily temperature*' OR 'ambient temperature'). The search included all papers published until November 1 2022. I defined the climate region according to the Köppen Geiger classification, incorporating geographical regions that were classified as Af (tropical, wet year-round) Aw (tropical, dry winter), and Am (tropical monsoon climate).[~~53~~ 43] According to the Köppen Geiger classification, the Torres Strait region is classified as Aw. Only papers describing the impact of heat on mortality in tropical regions were included in the review.

56. I found 25 articles that described the impact of increasing temperatures, heat and/or heat waves on mortality among people living in tropical regions.[54-78] Three of these were not included in the data analysis because, in my opinion, their statistical analyses were not appropriate to the research question.[71, 75, 76] The paper by Rathi and colleagues was one of the excluded papers. In contrast to the papers included in the review, the authors compared the mean (average) number of deaths during summer months for days when the daily maximum temperature was less than 35°C with days when the daily maximum temperature ranged between 35.5 and 40°C, and when the daily maximum temperature was over 40°C. The study used data from Surat, India and found an increase in the average number of deaths on days when the maximum

temperature was over 40°C compared to less than 35°C. In my opinion, this method does not account for the probability of other causes of increased deaths during the different summer periods. By averaging the deaths for each time points, their analysis did not take into account the range of numbers of deaths that occurred on days with the same maximum temperature range. That is why the methodology is not routinely used to assess the relationship between high ambient temperatures and mortality.[71]

57. Another paper that I excluded from the review was by Alam and colleagues.[75] Alam and colleagues used a statistical method that has been used in many other studies of the impacts of temperature on mortality. However, due to small population numbers they averaged both the temperatures (maximum, minimum and mean daily temperature) and the number of deaths by weeks. The study was conducted using data from Abhoynagar, Bangladesh and it did not find any association between high temperatures and mortality. In my opinion, averaging deaths over calendar weeks means that the impact of high temperatures on consecutive days across more than one week will be diluted by the inclusion of days without high temperatures on the other days of that week. For hot periods of only two or three days even in the same week, the impact of the high temperatures will have been diluted by the non-hot days in the week. [75]

58. The final paper that I excluded from the analysis was by Babalola and colleagues.[76] This paper investigated the association between monthly mean temperatures and infant and child (aged < 5 years) mortality. Similar to the paper by Alam and colleagues described in paragraph 57, Babalola and colleagues averaged temperatures across months, which did not account for the variability of temperatures across days within a month. This paper found a reduced infant mortality in a month for every 1°C increase in the mean monthly temperature in the previous month.[76]

59. Of the 22 papers that were included in the data analysis, five were from Bangladesh,[56, 57, 59, 60, 65] two of which involved data from Matlab, a rural region;[56, 57] four were from India,[68-70, 74] three of which involved data from the rural region of Vadu Health and Demographic Surveillance System (HDSS);[68, 69, 74] three were from Thailand;[55, 72, 77] two from Philippines;[62, 63] and one each from Vietnam;[58] Malaysia;[64] Senegal;[67] French overseas regions;[61] Puerto Rico;[78] and Brazil.[73] One study involved multiple cities including from Brazil, Colombia, Philippines, Thailand and Vietnam.[54]

Mortality in rural areas

60. Within one country, the impact of heat on mortality in rural areas may differ from the impact in urban areas due to a range of factors including reduced urban heat island effect leading to lower overnight temperatures (from rural areas usually being greener than in urban areas) and lower radiant temperatures, different socio-economic factors (including housing and access to electricity), and different rates of underlying chronic diseases. These differences between urban and rural areas will not be consistent in different countries or localities.[57] Nevertheless, I have summarised my findings for rural areas separately to urban.

61. Two studies used the same data sources from Matlab, Bangladesh, a rural area 57 km from Dhaka.[56, 57] Community-based surveillance (births, deaths and migrations) has been undertaken in Matlab since 1966 through monthly (until 2000) then bimonthly household visits.[56] The population included in the surveillance was 225,002 at the end of 2009.[56] Because of this small population, the studies have involved many years in a period when global average temperatures have been increasing rapidly, and this limits the utility of the studies. In their Matlab study conducted on data from January 1994 to December 2002 (with a total of 13,270 non-external deaths), Hashizume et al found no increase in all-cause mortality across the whole population for every 1°C above any threshold[j], but a very large increase in all-cause mortality (108% (32.3, 227.1)[k] per 1°C above a threshold of 31°C daily mean temperature) for people aged 65 years and older.[57] In a larger study by Lindebloom et al using the same data source from 1983 to 2009 (48,283 deaths) the authors found a 0.2% (0.1, 0.3) increase in all-cause mortality across all age groups per 1°C above a threshold at the 75th percentile (29.2°C) in daily mean temperature. The temperatures in the Matlab region were higher than in the Torres Strait, where the 75th percentile of daily mean temperatures from 2001 to 2022 was 28.6 °C.

62. A HDSS was initiated in Vadu, Pune, India. The system included 22 villages over 232 km^2, an average altitude of 560m, and a population of around 131,000 people. Three studies involving data from Vadu HDSS were conducted in periods from 2003 to 2013.[68, 69, 74] The study that was conducted using data for people aged 12 and over from 2003-2012 (2302 deaths),[69] found a 33% (7, 60) increased risk in all-cause mortality during days above the 98th percentile of daily maximum temperature (39°C). There was no increase in mortality for cold temperatures. A study conducted using data (3079 deaths) for people aged 15 years and older from 2004 to 2014,[68] found a non-linear[l] increase in mortality when the daily mean temperature was higher than 31°C. The authors investigated demographic factors that were associated with increased mortality. They found increased mortality for farmers compared to other occupational groups, women compared to men, and for people with lower education levels. There was no difference in mortality according to the house type and land ownership. The maximum and daily mean temperatures in Vadu, Pune, as described in the above studies were higher than on Horn Island from 2001 to 2022.

63. A study of the impact of heatwaves on mortality was undertaken in Bandafassi, Senegal, utilising data from 1973-2012.[67] Bandafassi is a rural area of Senegal with a population of around 13,000 people across a number of villages. Over the period of the study there were 6684 documented deaths (average of 0.27 deaths per day). Mortality increased with increasing severity and duration of heatwaves (compared to non-heatwave days).

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[j] The threshold is the temperature selected by the study authors above which changes in mortality are assessed. Different types of thresholds are used in different studies. These include a particular temperature nominated by the study authors, the calculated minimum mortality temperature (the temperature at which the lowest number of deaths have occurred), or a particular temperature percentile (usually the 75th and sometimes the 50th percentile)

[k] The numbers in parentheses are the 95% confidence intervals. Confidence intervals with a wide range, such as 32.3 (lower) and 227.1 (higher), reflect a low precision in the estimate. This is usually because of a small sample size.

[l] The rate of increase in mortality increased with increasing temperatures over the threshold

For example, a five-day heatwave with temperatures at the 87th percentile and above resulted in a 40% increase in mortality (20, 50), and a five-day heatwave with temperatures at the 92nd percentile and above resulted in a 50% increase in mortality (30, 80). A three-day heatwave with temperatures at the 95th percentile and above resulted in a 290% increase in mortality (220, 350). Children five years and under and adults aged 55 years and over had the higher mortality.[67] The maximum and daily mean temperatures in Bandafassi during the study ranged from 17.5 to 49°C (maximum temperature) and 16.1 to 39.8°C (mean temperature). While located in a tropical region, the temperature ranges and high temperatures were much greater than in the Torres Strait.

Mortality in urban or mixed urban and rural areas

64. Three studies in Bangladesh incorporated both urban and rural areas in their analysis.[59, 60, 65] All of these used mortality data from the Sample Vital Registration System, which involves a sample population of around one million people across the country. Two did different analyses on data from 2003 – 2007,[59, 60] and the other on data from 1989 – 2011.[65] While the sample is predominantly from rural areas across Bangladesh, Burkart and colleagues utilised climate-related information from a single urban centre. This was because the trends were similar across all areas. However, the rural areas were cooler. They found higher mortality in urban compared to rural areas for the same heat event but did not take into account the cooler temperatures in rural areas during the event. They used Universal Thermal Climate Index (UTCI) as the indicator of heat exposure. This index incorporates temperature, humidity, wind speed and radiant temperature. They found a 31.3% (24.5, 44.3) increase in all-cause mortality for all ages above 1 year for every 1°C above the 99th percentile of UTCI. The increase was higher in people aged 65 years and above compared to other age groups. There was an increase in cardiovascular mortality of 20% (10.6, 34.7) across all ages.[59, 60] Nissan and colleagues investigated potential different heatwave definitions that would trigger the issuing of a warning. The data were aggregated across all areas included in their modelling. They found a 22.3% (8.2, 38.2) increase in mortality on the third day of a heatwave where the day and night temperatures were both greater than the 95th percentile. When they considered day and night-time temperatures and humidity exceeding the 95th percentile, the increase in mortality was 24.0% (9.8, 40.2), which is not statistically significantly different from the estimate when humidity was not included. The mean daily temperatures in the study areas for the above three studies was similar to those at Horn Island in the Torres Strait.

65. Three studies investigated the impact of heat on mortality in Thailand.[55, 72, 77] Two of these utilised data from 60 provinces across Thailand (87% of the Thai population),[72, 77] while the other focussed on Chiang Mai city.[55] Huang and colleagues investigated the impact of low (90th to 93rd percentile), medium (94th to 96th percentile) and high (97th to 99th percentile) heatwaves of two to four or more days duration in the four hottest months of 1998 to 2008.[72] Across the 60 provinces, there was a 11.3% (10, 13) increase in mortality for the 'acute' impacts (0 – 1 days) of low intensity, 12.0% (10.3, 13.8) of medium intensity and 12.6% (10.3, 15.0) for high intensity heatwaves. The cumulative impacts of the heatwaves (ie more than 1 day afterwards) was higher for low and

medium intensity, but not for high intensity heatwaves. For the cumulative impacts, there was a 16.9% (13.1, 20.8) increase in mortality for low, 15.5% (11.0, 20.1) for medium, and 12.6 (6.9, 18.6) for high intensity heatwaves. In my opinion, this may be because high intensity heatwaves are more likely to lead to death immediately, with the deaths due to exacerbation of chronic conditions and infectious diseases occurring later. The authors found that the largest cause of increased mortality for acute and cumulative impacts of low intensity heatwaves was infectious diseases. Ischaemic heart disease was the leading cause of excess deaths in the acute phase and infectious diseases was the leading cause of death for the cumulative impacts of medium and high intensity heatwaves. They found that a higher impact of low and medium intensity heatwaves on mortality occurred in provinces with populations with a higher proportion of older people, but there was no difference between provinces on the impact in mortality for high intensity heatwaves.[72] This suggests that while older people are more susceptible to the impact of low and medium intensity heatwaves, high intensity heatwaves are likely to affect all ages.

66. Using a different study design to Huang et al, He and colleagues investigated the acute (0 – 1 day) impact of heat (90th percentile) and extreme heat (99th percentile) on diabetes mortality across the year in 2000 to 2008.[77] This study was located in the same 60 provinces as the study by Huang et al.[72] Across the country there was an increased risk of diabetes mortality (odds ratio[m] (OR) 1.10 (1.06, 1.14) for heat and OR 1.20 (1.10, 1.30) for extreme heat. Having more green space reduced the risk of death, and there was a difference in the impact between provinces, with the highest risk being in Bangkok.[77]

67. Guo and colleagues investigated the impact of temperature on mortality in Chiang Mai city, Thailand from 1999 to 2008.[55] They found a 20% (13, 27) increased acute (days 0 – 2) risk of mortality on days with temperature in the 99th compared to the 75th percentile. The increased mortality for people aged 64 years or less was 20% (13, 27), with a 19% (6, 34) increase for people aged 65 to 84 years and a 33% (8, 64) increase in mortality for those aged 85 and older.[55]

68. The mean and maximum daily temperatures in the study areas for the three studies in Thailand described in paragraphs 65 to 67 were similar to those at Horn Island in the Torres Strait.

69. In another study, Guo and colleagues investigated the impact of heatwaves on mortality in a large number of cities around the world. This included 19 cities with a tropical climate from Thailand (63 cities), Brazil (15 cities), Colombia (4 cities), Philippines (4 cities), Florida, USA (4 cities) and Vietnam (2 cities). The time period of the data varied: Colombia (1998 – 2013 – 16 yrs), Brazil 1997-2011 – 15 yrs), Thailand (1999-2008 – 10 yrs), Vietnam (2009-2013 – 5 yrs), and Philippines (2006-2010 – 5 yrs).[54] Excluding Florida, heatwaves at or above the 97.5th percentile resulted in an increase in mortality of four to 16% per day. There was no discernible impact in some Florida cities, perhaps

[m] An odds ratio is a different measure of association than a relative risk or risk increase. An odds ratio cannot be translated into a risk increase/decrease. An odds ratio greater than one signifies an increased risk.

due to access to air-conditioning. The largest mortality impacts were in the Philippines, ranging from a 15% (8, 22) increase in Davao to 16% (10, 23) in Quezon. Prolonged heatwaves resulted in increased duration of mortality after the heatwave.[54]

70. A study in the historic city of Hue, Vietnam that utilised data from 2009-2013 found large increases in mortality on hot days at or above the 99th percentile. The daily increase in all-cause mortality up to 2 days following the high temperatures was 28% (4, 58). The mortality was highest for cardiovascular disease with a 60% (15, 222) daily increase in mortality. The daily mortality in people aged 65 or more was 42% (11, 83).[58] In the study period the mean daily maximum temperature in Hue was 29.9°C and the mean daily mean temperature was 25.7°C, which is less than the equivalent measures on Horn Island from 2001 to 2022 (mean daily maximum temperature 30.6°C and mean daily mean temperature 27.7°C).

71. Yatim et al conducted a study in the Selangor Valley of Malaysia, which is highly urbanised.[64] Using data from 2006-2015 they found an increase in daily non-external mortality of 9% (2, 17) for up to 3 days following the daily mean temperatures at or above the 99th percentile compared to the minimum mortality temperature (daily mean temperature 28.2°C). There was an increase in cardiovascular mortality of 33% (17, 82) and of respiratory mortality of 42% (4, 236) for up to 14 days following the temperatures at or above the 99th percentile compared to the minimum mortality temperature. There was minimal increase in mortality due to cold temperatures at or below the 1st percentile.[64] The mean daily mean temperature in the study period was the same as on Horn Island (27°C), but the mean daily maximum temperature was higher at 32.1°C, suggesting a greater temperature range than in the Torres Strait.

72. Dutta and colleagues conducted a study in the urban area of Bubaneswar, India using data from the summer months in 2007 – 2017. They found a 13% (3, 25) increase in daily mortality for up to 5 days following hot days in the 95th percentile (41.4°C) and above of daily maximum temperatures, and a 38% (13, 69) increase in daily mortality for up to 5 days following days with temperatures in the 99th percentile (43.5°C) and above of daily maximum temperatures compared to the minimum mortality temperature (maximum temperature of 36.2°C).[66] The 95th and 99th percentile temperatures are significantly higher than the maximum temperatures that have been recorded in the Torres Strait.

73. Geirinhas and colleagues undertook a study of the impact of excess heat on mortality in Rio de Janeiro using data from 2000 – 2015 in the summer months only. They found a 6% (5, 7) increase in daily mortality among people aged 60 and above, up to 2 days following mean daily temperatures on or above the 90th percentile compared to the mean daily mortality across the same time period. The major causes of death were cardiovascular, respiratory and diabetes.[73] The maximum temperatures in the study period in Rio de Janeiro were higher than on Horn Island in the Torres Strait, but in contrast to the study undertaken by Dutta and colleagues[66] they did not exceed 40°C. Rio de Janeiro differs from the Torres Strait in many other ways, including population density and in having slum communities with very poor housing.

74. Seposo and colleagues undertook two studies utilising mortality data from cities in the Philippines from 2006-2010.[62, 63] The first study investigated the impact of daily mean temperature on mortality in Manila city. They found that there was a non-linear 7% (0, 15) increase in all-cause mortality compared to the minimum mortality temperature (30°C) on days when the temperature was on or above the 95th percentile, and a 40% (22, 61) increase in all-cause mortality on days when the temperature was on or above the 99th percentile. Mortality was highest among people aged 65 and above and cardiovascular and respiratory diseases were the main cause of death.[62] The mean of the mean daily temperature in Manila City during the study period was 28.8°C, which is around 1°C higher than on Horn Island, Torres Strait. The second study investigated the impact of heatwaves (>2, >4 and >7 days of high temperatures) on mortality in Manila city, Quezon, Cebu and Davao in the hottest months of the year in the years 2006 - 2010. Compared to days where the temperature was at the 75th percentile, there was similar daily mortality in heatwaves of different duration. There was a 14% (4, 25) increase in daily mortality on heatwave days at or above the 95th percentile, and a 23% (5, 43) increase in daily mortality on heatwave days at or above the 97th percentile. The mortality was highest in children up to 14 years and the highest cause of death was respiratory illness.[63] As with the study in Manila, the mean maximum temperatures were between 1 and 2°C higher in the four study sites in the Philippines compared to Horn Island, Torres Strait. These cities differ from the Torres Strait in a range of different ways including population density and having slum communities with very poor housing.

75. Norisama and colleagues investigated the impact of heatwaves on mortality in four cities of which Mumbai is the only tropical city using data from 2000 – 2012. Using data for people aged 35 years and above, they found a 7% (3, 12) increase in daily mortality during heatwaves with the daily mean temperature on or above the 97th percentile (30°C) compared to non-heatwave days In Mumbai. There were more deaths during heatwaves later in the season in Mumbai compared to earlier in the season.[70] The mean maximum temperature in Mumbai across a typical year is 37.6°C, which is considerably higher than on Horn Island in the Torres Strait (30.6°C) Mumbai differs from the Torres Strait in a range of different ways including population density and having slum communities with very poor housing.

76. Using data from 2000 – 2015, Pascal and colleagues investigated the impact of heat on mortality in four tropical towns in French territories in the French Caribbean and in French Guyana. While two of these towns were on tropical islands, they had populations of greater than 100,000 people, making it difficult to extrapolate findings to the Torres Strait. Across all four towns they found a 20% (6, 42) increase in daily mortality up to 10 days after days with temperatures at or above the 99th percentile (ranging from 28.4°C to 29.4°C across the four towns) compared to the minimum mortality temperature, which ranged from 23.8°C to 27.5°C across the four towns.[61] The mean temperatures in all four towns were similar to those recorded on Horn Island, Torres Strait.

77. Mendez-Lazaro and colleagues did a study of the association between heat and mortality in two municipalities (San Juan, population over 380,000 people and

Bayamon, population over 200,000 people) in Puerto Rico. They used temperature and mortality data from 2009 to 2013. They found a statistically significant increase in the relative risk of death on days when the maximum temperature exceeded 31.1°C compared to the other days in the summers of 2009, 2010, 2012, 2013, but not in 2011. The relative risk for death on days when the maximum temperature exceeded 31.1°C compared to the other days in the summers of 2012/2013 was higher than in the summers of 2009/2010. At the time when the study was undertaken, 2012 and 2013 were the hottest years on record in Puerto Rico. They found that the increased risk of non-accidental mortality on days when the maximum temperature exceeded 31.1°C compared to the days when the maximum temperature was less than 30°C was 1294 times higher (976,1716) in 2012/2013 and 987 times higher in 2009/2010. Stroke (increased risk 1680 (681, 414) times higher) and cardiovascular diseases (increased risk 1663 (1047, 2642) times higher) were the causes of non-accidental death with the highest association with high temperature in the summers of 2012/2013. Renal conditions (increased risk 1625 times higher), hypertension (increased risk 1178 times higher), respiratory conditions (increased risk 1117 times higher) and pneumonia (increased risk 1067 times higher) were the causes of non-accidental death with the highest association with high temperature in the summers of 2009/2010. 95% confidence intervals were not provided for the risk estimates for 2009/2010, but the point estimates (the best estimate) of the risk estimates were statistically significant.[78] In my opinion it is noteworthy that the differences in mortality were so large between days with maximum temperatures above 31.1°C compared to days with maximum temperatures of below 30°C, a difference in cut-off temperatures of only 1.1°C. In my opinion it is likely that the relative risk of mortality in the summer months of 2012/2013 is so much higher than in 2009/2010 because the actual maximum temperatures that were above 31.1°C were much higher in 2012/2013 than they were in 2009/2010. The risk estimates in this study are much higher than in the other studies. This is because Mendez-Lazaro and colleagues used a different methodology to the other studies. They do not provide much detail about their methods, which makes it difficult for me to assess whether or not the methods are valid beyond the peer review. It is clear that their analytical approach had a big impact on the magnitude of their findings. Rather than considering their absolute risk estimates, it is my opinion that we should instead focus on their overall findings, which was that, in a climate where the temperature variation across the year is small, increasing temperatures above a daily mean of 30°C resulted in increased mortality due to a range of causes. The daily maximum and mean temperatures in this study were similar to those recorded on Horn Island, Torres Strait.

78. As you can see from paragraphs 60 to 77, there is limited literature on the impacts of heat on mortality (death) in tropical areas, and many of the studies that were undertaken used data from as far back as 1994 to up to 2015. While hotter than pre-industrial times, the increases in temperatures in earlier decades are not as high as the present time, and the studies may not reflect current conditions. There were methodological differences between the studies, which mean it is not possible to do a formal metanalysis (when data from different studies are combined). With the exception of Florida in the larger study by Guo et al[54] (paragraph 69), all of the studies found an increase in mortality associated with high temperatures in tropical regions. In general, the mortality increased with increasing temperatures. There were differences

in the degree of increase in mortality that reflected different climates, housing and living conditions and temperature thresholds. Five of the studies were conducted in tropical areas with maximum temperatures that were much higher than in the Torres Strait (two of these in the same study region).[66, 67, 69, 70, 74] Even with these studies being excluded, on the basis of the consistency of the findings from the literature in my opinion it is likely that Torres Strait Islander people will already be experiencing increased mortality (particularly older people, those living with chronic diseases and the very young). It is also my opinion that these impacts are likely to increase with increases in global average temperature. The susceptibility of Torres Strait Islander people to the impacts of heat is increased due to a range of factors outlined in my response to Question 4.

Indirect impacts – fresh water availability and quality

79. Access to clean and safe fresh water is essential for life.[79] Access to clean and safe fresh water is not only important for maintaining hydration and for food preparation, it is also important for hygiene. Challenges with fresh water availability occur when there is an insufficient supply as well as when there is an adequate supply of fresh water but the water is contaminated with microorganisms, toxins or chemicals.

80. Fresh water can be contaminated with microorganisms, which can cause disease if the microorganisms are pathogens. Contamination of drinking water with pathogenic microorganisms (microorganisms that can cause disease; these include bacteria, viruses and protozoa) is the greatest source of risk to consumers in relation to drinking water.[79] Faecal contamination of water supplies (from humans or other animals) is the most common source of microbiological contamination. Floods and heavy rainfall increase the risk of contamination, as microorganisms can be flushed from the soil into drinking water supplies.[79] To prevent the contamination of drinking water with pathogenic organisms, multiple barriers are required. These include protecting the source from faecal contamination, disinfection (usually with chlorine, and requiring maintenance of protective chlorine levels in water throughout its distribution) or filtration. High levels of turbidity (cloudiness) of water can inhibit the effectiveness of chlorination as a disinfectant.[79]

81. Fresh water supplies can also become contaminated by blooms of cyanobacteria, which usually occur when the water temperature increases and when there are excess nutrients (particularly nitrogen) in the water. Some cyanobacteria can release toxins that can be harmful to humans from either drinking or from direct skin contact (eg while washing). In Australia most outbreaks of toxin-releasing cyanobacteria have occurred in the Murray Darling Basin. However, blooms of species of cyanobacteria have occurred across Queensland, causing deaths of cattle, and, according to investigators was most likely the cause of a 'mystery disease' among 148 residents of Palm Island in 1979 following contamination of water in a dam that was a source of drinking water on the island.[79] No other outbreaks of human disease related to these particular cyanobacteriae species have been described in Queensland.[79]

82. Fresh water can also become contaminated with salts, including sodium chloride, which can make water unpalatable and unsafe for human consumption, depending on the concentration.[79] Water can also become contaminated with heavy metals, including from the impacts of mining as well as burning of fossil fuels (for example, mercury).[79]

83. There are a number of different fresh water sources for Torres Strait Islander people living in the Torres Strait, depending on the time of year and on the island location. These include surface water (in lagoons or from creeks), bore water (wells), desalination plants and some rainwater harvested from roofs.[26, 80] Thursday Island, Horn Island, and Hammond Island (Kirriri) (via Thursday Island) rely on surface water from a creek (Loggy Creek) stored in a dam on Horn Island. Pumped water from Horn Island is stored in reservoirs on Thursday Island and Kirriri Island.[26, 81] Existing challenges with fresh water in Torres Strait on some islands include contamination with *Escherichia coli* (a marker for faecal contamination and insufficient chlorination), turbidity (making chlorination less effective), intermittent supply and in some cases reliance on household rainwater tanks with opportunities for microbiological contamination from roofs and gutters.~~[80]~~ [26] Factors contributing to these challenges include inadequate and inappropriate technology, insufficient training and support for staff and limited options for water sources on some islands.[26]

84. Of the 15 Torres Strait islands whose water supply is managed by the Torres Strait Island Regional Council, 11 rely in part on freshwater lagoons replenished by rainwater. Based on the assumption that increased global average surface temperatures is resulting in increased variability of rainfall in the Torres Strait, it is likely that lagoons and household rainwater tanks will become less reliable as a source of fresh water. As outlined in paragraph 80, floods and heavy rainfall can increase turbidity and microbiological contamination of surface water.[79] On this basis, it is my opinion that both the increased variability of rainfall in the Torres Strait and increasing temperatures can also affect the source water quality due to increasing risk of microbiological contamination. Heavy rainfall can increase the risk of microbiological contamination and turbidity of lagoon water due to increased runoff into the lagoons. Low lagoon levels due to low rainfall also increases the risk of increased turbidity due to the potential for contamination of the water from silt from the base of the lagoon. Thus, both low and high rainfall impacts on the first barrier to microbiological contamination of drinking water (reducing contamination at the source) and/or the second barrier (disinfection), because, as described above, turbidity inhibits the effectiveness of chlorination as a disinfectant.

85. In 2020, ~~four~~ three Torres Strait islands required boil water alerts on at least one occasion, encouraging residents to boil their water before drinking and food preparation. ~~Two~~ One island~~s, Boigu and~~ Erub had ongoing boil water alerts.[80] An alternative to boiling water is the consumption of bottled water, which incurs increased cost and results in increased plastic waste. Barriers to compliance with boil water alerts include increased electricity costs, insufficient options for storage of boiled water, and a failure to understand the alert. Long-term boil water alerts have poorer compliance than short term alerts.[82] In my opinion, the requirement to boil all drinking water also increases the risk of burns and scalding. As stated in paragraph 84, it is my opinion that there is likely to be an increase in microbiological contamination of drinking water on at least

some of the islands of the Torres Strait as a result of increasing global average temperatures. Based on this and on the finding in other settings that compliance with long-term boil water alerts tends to be poor, it is my opinion that gastrointestinal infections will increase among people living in the Torres Strait as a result of climate change due to increased microbiological contamination of drinking water. The risk of burns and scalding from the increased need to boil drinking water may also increase with increases in global average surface temperatures.

86. In 2020, seven Torres Strait islands had groundwater (wells) as part of their fresh water supply. Sea level rise is already resulting in sea water incursion into groundwater in a number of coastal areas around the world.[83] Based on the assumption that increased global average surface temperatures has resulted in sea level rise that will continue to increase with increasing global average temperatures, it is my opinion that sea water incursion into groundwater supplies on Torres Strait Islands will reduce the availability of freshwater and result in increasing reliance on desalination.

87. Based on the assumption that increases in global average surface temperatures will reduce the availability of drinking water in the Torres Strait, it is my opinion that reduced availability of drinking water could result in increased dehydration, particularly on hot days. This would increase the risk of heat stroke and acute kidney failure on hot days. Chronic dehydration also increases the risk of chronic kidney failure, as has recently been described in Central America.[84] The combination of increasing heat and dehydration therefore has significant negative impacts on health.

Indirect impacts – availability of healthy foods

88. For the purpose of this report I assume that increasing global average surface temperatures will decrease the availability and quantity of traditionally sourced foods, including dugong, turtles, and traditionally grown crops. As outlined in paragraph 26, the cost of store-purchased food in the Torres Strait is considered unaffordable by Australian standards and the quality of store-bought fresh food is poor on some of the outer islands. Therefore, traditionally sourced foods are an important adjunct to store-bought foods for some Torres Strait Islander peoples. At the recent Torres Strait & Northern Peninsula Area Regional Communities forum (2023), participants identified promoting and supporting family and community gardening as a way of addressing food insecurity.[10] According to the Australian dietary guidelines, a healthy diet meets all requirements for essential nutrients while not containing an excess of sugar and fat. For adults this includes two serves of fruit and five serves of vegetables per day.[85] A diet with an excess of sugar and fat increases the risk of diabetes and heart disease, and is a major cause of chronic disease in the Torres Strait and in the rest of Australia.[14] In my opinion, decreased access to traditionally sourced foods will therefore further worsen the nutritional status of and worsen food insecurity for Torres Strait Islander people living in the Torres Strait.

89. Ciguatera poisoning is a neurological condition resulting from the consumption of potent neurotoxins in fish.[86, 87] The toxins accumulate in fish and in humans when the fish is consumed. Symptoms include tingling of the skin, joint pain, burning of the skin when in contact with cold water, headaches and fainting. The symptoms can last for three months or more and can recur with further exposure.[86, 87] The toxins are produced by small microorganism called a dinoflagellate, which attaches itself to warm water algae. When the algae are consumed by fish, the toxin produced by the dinoflagellate accumulates in the fish. Large fish that have consumed many small fish pose the highest risk of causing ciguatera. The algae and dinoflagellate increase with warming water and the incidence of ciguatera poisoning is increasing in many small island states in the Pacific.[86] To my knowledge ciguatera poisoning has not been documented in the Torres Strait. Given the warm ocean temperatures this could be due to other factors such as ocean currents. On this basis it is my qualified opinion that the risk of ciguatera poisoning could increase among Torres Strait Islander people as global average surface temperatures increase. If this is to occur, it would have direct consequences for the health of people affected by ciguatera and could also have the effect of dissuading people to consume locally caught fish in the Torres Strait, with consequent negative impacts on nutrition and health as well as on cultural wellbeing.

90. [redacted]

Indirect impacts – infectious diseases

91. The global distribution of many infectious diseases reflects a range of factors including local ecosystems, socioeconomic factors including access to health care and local climates. The incidence and prevalence of tuberculosis, for example, reflects living conditions (levels of crowding, indoor air pollution) and, in particular access to and awareness of early detection, prevention and treatment services.[89] Malaria is another example of the complex interplay of ecosystem, local climate, socioeconomic factors and healthcare. Historically, malaria vector mosquitoes were more widespread in Australia than they currently are, and malaria transmission has occurred in the Northern Territory and North Queensland.[90] The global response to malaria involves vector control, protection from mosquito bites, prophylactic medications and detection and treatment.[91] Land use, with resultant changes in local ecosystems, can also impact on the distribution and incidence of infectious diseases.[92] For example, a study involving mosquito trapping on Saibai, Boigu, Badu and Moa islands in the Torres Strait was undertaken by Steiger and colleagues. They found that mosquitoes involved in transmitting vector borne diseases such as dengue and malaria were more common in villages than in parts of the islands that were covered by 'natural' vegetation.[93]

Mosquitos have optimal temperature and humidity conditions for breeding and for pathogens to reproduce within them. Some places may become too hot or too dry for particular vector mosquitoes to thrive. Therefore, increasing global average surface temperatures may result in decreases in the transmission of dengue and other mosquito borne diseases in some areas, and increases in others.[94] Based on this information, in my opinion we do not know what the impact of increasing global average surface temperatures on dengue and other mosquito borne diseases in the Torres Strait will be. Another important factor is that an increased dependence on rainwater tanks in the Torres Strait, if they are poorly maintained, and other water hoarding as a result of increasing water insecurity could increase the number of breeding sites for *Aedes albopictus* and *Aedes aegypti* (the vectors for dengue, Chikungunya and Zika viruses).[95]

92. In my opinion gastrointestinal infections are the infections that are most likely to increase in the Torres Strait as a result of climate change. There are several reasons for this. Firstly, increased ambient temperatures result in increased reproduction of bacterial pathogens in unrefrigerated food.[23, 24] Therefore, it is likely that there will be increases in Salmonella and Campylobacter and other bacterial foodborne infections among Torres Strait Islander people living in the Torres Strait. Secondly reductions in the quality and availability of drinking water (paragraphs 83 to 87), could result in the increase of gastrointestinal infections (including *Salmonella, Campylobacter,* giardia and norovirus infections) due to the consumption of contaminated water and possibly a reduction in hygiene practices due to water shortages.

93. On low-lying islands of the Torres Strait, rising sea levels will result in saltwater intrusion into wastewater (sewerage) treatment facilities, which can then cause the system to malfunction. When that occurs, the mix of sewerage and saltwater will have to be pumped out into the surrounding sea.[13] Apart from the aesthetic impacts (olfactory and visual), this could increase the risk of algal blooms due to higher nitrogen levels with potential toxin release leading to skin and eye irritation.[96] In addition, the presence of untreated sewerage in coastal waters can increase the risk of gastrointestinal disease if people swim in the water.[97] The gastroenteritis can be caused by a range of bacterial, protozoal and viral pathogens. For example, norovirus is a highly infectious virus that causes vomiting and diarrhoea, sometimes severe. Norovirus in sea water from untreated sewerage can get into shellfish, and human infections have occurred from consumption of raw contaminated shellfish.[98] Norovirus can survive for many months in seawater and it is also possible to contract norovirus infection from swimming in contaminated seawater through ingestion. Norovirus has a small infectious dose (does not require many norovirus particles to cause an infection), so it is of particular concern.[99] Other infections that can be acquired through swimming in the sea when it is contaminated include skin and eye bacterial infections and occasionally respiratory infections.[97] Based on these findings from other places and on my assumption of rising sea levels in the Torres Strait as a result of increases in global average temperatures, it is my opinion that increasing global average temperatures will likely increase the risk of gastrointestinal infections and skin and eye bacterial infections as a result of an increasing risk of contamination of sea water with untreated sewerage.

Indirect impacts – Cultural and emotional wellbeing

94. [redacted] Research has shown that caring for country has positive benefits for the health of Aboriginal people resulting in reduction of risk factors for chronic disease.[15]

95. Practicing 'Ailan Kastom' (Torres Strait Islander peoples' cultures) is also beneficial to the health and wellbeing of Torres Strait Islander peoples.[13, 88] [redacted]

Q.4 Are Torres Strait Islanders more vulnerable to the effects on human health you identified in response to Q.3 of the Torres Strait Impacts, as compared to the general Australian population? If your answer is yes, explain why and in what respects.

96. Yes, in my opinion, Torres Strait Islander peoples living in the Torres Strait are more susceptible to the health impacts of climate change compared to the general Australian population. Note I am using the term 'susceptible' rather than 'vulnerable' because the term 'vulnerable' implies an implicit deficit among individuals and populations, rather than examining the underlying causes of health inequities.[102] When using the term 'susceptible' I am referring to the level of risk faced by Torres Strait Islander peoples living in the Torres Strait, which makes them a priority population with respect to responding to the threats of climate change.

97. Torres Strait Islander peoples living in the Torres Strait are more susceptible to the impacts of climate change on their health for the following reasons:

History of colonisation and impacts of systemic and institutional racism

98. As described in paragraphs 22 and 23 the impact of colonisation and subsequent systemic and institutional racism on the health and wellbeing of Aboriginal and Torres Strait Islander peoples has had a negative impact on the social determinants of their health.[10, 15] In spite of the considerable and ongoing strengths and resilience of Torres Strait Islander peoples, these impacts are significant in the Torres Strait.[10] This includes, for example, lower incomes, higher reliance on welfare payments, and lower education outcomes compared to the general Australian population.[2] The impacts on social determinants of health are not uniform among all Torres Strait Islander peoples living in the Torres Strait.[10] In my opinion the impacts of colonisation and systemic and institutional racism increase the susceptibility to further stressors such as climate change as a result of their impacts on the social determinants of health.[103]

Inappropriate housing and insufficient access to and vulnerability of infrastructure for good health

99. As outlined in paragraph 46, housing on some islands in the Torres Strait is not well-adapted for heat, with poor ventilation, limited ventilation in ceilings and the use of building materials that retain heat.[35] In addition, many households in the Torres Strait are not airconditioned and do not have ceiling fans.[35] [redacted]. In my opinion, this increases the susceptibility of Torres Strait Islander peoples to the negative health impacts of heat. In addition, there is insufficient housing on many Torres Strait Islands, and many houses are crowded.[2] In my opinion, this increases susceptibility to a range of infectious diseases, some of which, such as gastroenteritis, may be exacerbated by climate change.

100. The challenges with water supplies on many islands as outlined in paragraphs 83 to 86 mean that Torres Strait Islander peoples are more susceptible to the impacts of climate change. Many Australians living in cities have experienced water restrictions during droughts, [104] and are likely to do so again in the future.[105] Sydney experienced the need for boil water alerts following detection of the pathogens *Cryptosporidium* and *Giardia* in their water sources in 1998.[106] [redacted]

101. [redacted]

[redacted]

High rates of chronic diseases among Torres Strait Islander people living in the Torres Strait

102. The high rates of chronic diseases among Torres Strait Islander people living in the Torres Strait as described in paragraphs 12 to 21 increases their susceptibility to the impacts of heat on health and mortality. Based on the observations that an important way that heat increases morbidity and mortality is through exacerbation of chronic diseases as outlined in paragraphs 44, 49, 51, 65, 66, 73 and 77, in my opinion the high rates of chronic diseases significantly increase the risk of morbidity and mortality due to increasing high temperatures as a result of increases in global average temperatures.

Geographical location of the Torres Strait Islands and their climate prior to increases in global average surface temperatures.

103. The tropical location of the Torres Strait Islands means that the islands already experience high temperatures as described in paragraph 43. According to some researchers, this could mean that there may be limits to the amount that temperatures and humidity can increase before human physiological heat-tolerance limits are reached.[34]

Proximity of the Torres Strait Islands to Papua New Guinea and West Papua

104. The proximity of Torres Strait Islands to Papua New Guinea and West Papua has resulted in important cultural, trade and family relationships, as recognised in the Torres Strait Protected Zone within the Torres Strait Treaty,[108] However, the low socio-economic status and poor access to health and other services of people living in the bordering Western Province of Papua New Guinea means that this proximity increases the risk of exposure to a number of infectious diseases, which may increase as a result of increasing global average temperatures (see paragraphs 30 to 32). In addition, population expansion in Southern Papua New Guinea and a growth in fisheries and forest clearing for palm oil production may impact on fish stocks and water quality in the Torres Strait, [13] which could exacerbate the impacts of climate change. As it is not known what impacts climate change will have on the incidence of infectious diseases in Papua New Guinea and West Papua, this is a qualified opinion.

[redacted]

[redacted]

[redacted]

106. [redacted]

107. [redacted]

[redacted]

108. [redacted]

109. [redacted]

110. [redacted]

111. [redacted]

[redacted]

Declaration

I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance that I regard as relevant have, to my knowledge, been withheld from the Court.

Linda A Selvey, 28 April 2023.

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LINDA A. SELVEY,
MBBS(Hon), BMedSci(Hon), M.App.Epi, PhD, FAFPHM.

Curriculum Vitae

Relevant Work Experience

Associate Professor Division of Planetary Health and Health Protection, School of Public Health, University of Queensland Sept 2019 to present

Associate Professor and Head of Division of Disease Prevention and Control, School of Public Health, University of Queensland January 2017 to Sept 2019

Major Responsibilities

- Lead and manage the Division of Disease Prevention and Control, the largest Division within the School of Public Health (until Sept 2019)
- Theme lead for Advocate for Health Improvement MD design (new program that commenced in 2023)
- Lead the teaching of public health within the MD program
- Undertake relevant teaching including climate change and health and social determinants of health within the MD program
- Redevelop and teach Communicable Diseases Control course (2019)
- Undertake research and supervise PhD students

Major Achievements (in 5 years)

- Formed and chaired the Queensland Hepatitis C Elimination working party, which wrote a Queensland Hepatitis C Elimination Framework and work plan, and a reporting framework
- Obtained eight research grants totalling over $2.93 million, including a prestigious NHMRC Ideas grant.
- Published 61 peer-reviewed manuscripts and five reports
- Supervised nine PhD students to completion and a further three students who are currently under supervision

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Associate Professor, Public Health, Curtin University. Included roles as Director, Epidemiology and Biostatistics (2013 – 2016) and Deputy Head of School (2012 – 2013) Feb 2012 to December 2016

Major responsibilities

- Developed and taught two courses, one of which was 'Epidemiology of Infectious Diseases', the other was 'Public Health Response to Climate Change'
- Lead and manage staff
- Undertake research and supervise PhD students

Major relevant achievements

- Worked in the WHO Philippines Country Office as a GOARN (Global Outbreak Alert and Response Network) deployee for one month following Typhoon Haiyan (November/December 2013). *Led the successful implementation of the Philippines Emergency Surveillance system (SPEED) across the typhoon-affected areas.*
- Worked in Liberia as a GOARN deployee for 5 weeks supporting the Ebola response (January/February 2015). *Was appointed WHO Field Coordinator for Montserrado county, the only county in Liberia to have ongoing Ebola transmission in that time, and also the largest county, encompassing the capital Monrovia.* Formed and led a team of 16 people, strengthened the partnership between WHO and other organisations including CDC and the African Union, and supported the government's response. Supported the implementation of a new organisational structure for the Incident Management System in Montserrado. Achievements included strengthening of: data management; monitoring and support of contact tracing; case investigation; and infection prevention and control (particularly in private clinics in high-risk areas). I also played a key role in helping to resolve conflicts between partners and ensuring that non-government partners aligned in promoting the response.

CEO Greenpeace Australia Pacific **October 2009 to September 2011**

Executive Director Population Health Queensland **September 2005 to July 2009**

Major Responsibilities:

- Responsible for the statewide strategic planning, policy, coordination and development for population health in Queensland, grouped into the following units/branches: Communicable Diseases, Environmental Health, Health Promotion, Information Systems and Data management, Multicultural Health, Population Health Planning and Development, Chronic Disease Strategy, Cancer Screening Services, and three regional/area Population Health Services.
- Also responsible for primary health care within all Queensland Corrections Centres (Offender Health Services).
- In this role I was involved in a range of National committees, including Australian Population Health Development Principal Committee (Deputy Chair), Blood Borne Virus and STI Subcommittee of the APHDPC (Chair), Food Regulation Standing Committee, and was one of two state/territory members of the National Preventative Health Taskforce.

Director Communicable Diseases Unit, Queensland Health
Jan 2005 to October 2005 and Dec 1996 to February 2003

Major Responsibilities

- Around 50 staff and a budget of around $40 million
- Responsible for coordinating and setting the policy direction for communicable disease prevention and control throughout the state of Queensland (includes immunisation, arbovirus and vector control, infection control, blood borne viruses and HIV/AIDS). Also performed statewide surveillance for communicable diseases. Was

the Queensland representative on the Communicable Diseases Network of Australia (CDNA).

Qualifications

Registered Medical Practitioner (as a Specialist – Public Health Medicine) with the Australian Health Practitioner Regulation Agency.

College membership:

1998	Fellow, Australian Faculty of Public Health Medicine

Tertiary Studies:

1996	Master of Applied Epidemiology (Field Epidemiology Training Program), Australian National University
1991	PhD, Viral Immunology, University of Queensland
1986	Bachelor of Medical Science with Distinction, University of Queensland.
1983	Bachelor of Medicine and Bachelor of Surgery with 2nd Class Honours, University of Queensland.

Reports:

Selvey LA, Burns S. 2018. Increasing completion of HPV vaccination in Western Australian Schools: a formative study.

Hall N, **Selvey L**, Go-Sam C. 2018. Evaluation report: safe and healthy drinking water in Indigenous local government areas. Pilot – Torres Strait Region (Phase 2). Summary Report. Report for Queensland Health.

Hall N, Barbosa MC, Currie D, Dean AJ, Head B, Hill PS, Naylor S, Reid S, **Selvey L,** Willis J. 2017. Water, sanitation and hygiene in remote Indigenous Australian communities: a scan of priorities. *Global Change Institute discussion paper: Water for equity and wellbeing series.* The University of Queensland, Brisbane.

Selvey L, Hallett J, Lobo R, McCausland K, Bates J, Donovan B. The Law and Sex Worker Health (LASH). May 2017. Report for the Western Australian Department of Health

Selvey L, Slimings C, Adams E, Manuel J. The impact of a sexual health clinic targeting men who have sex with men (M Clinic) on HIV testing and risk behaviour. 2017. Report for the Western Australian AIDS Council

Linda Selvey, Robert Hall, Delia Hendrie, Catarina Antao, *2013.* **Development of an Evidence Compendium and Advice on Travel-related Measures for Response to an**

Influenza Pandemic and Other Communicable Diseases. Report for the Department of Health and Ageing.

Linda Selvey (*Chair*), Ian Anderson, John Mathews, Sally Redman, Stuart Shapiro, *July 2002.*
Report of the 2002 review of Strategic Research and the National Centres in HIV research. ***Commonwealth of Australia.*** (Part of the Review of the National HIV and Hepatitis C strategies).

Linda A Selvey and John W Sheridan, *November 2002.* The Health Benefits of Mitigating Global Warming in Australia. *Available at:* http://www.cana.net.au

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Committee membership (abbreviated):

2022–present Chair, Climate Change and Health Working Group, Royal Australasian College of Physicians (RACP).

2021–present RACP representative, Climate Change and Health Multi-college Advisory Committee.

2018 - 2020 President, Australasian Faculty of Public Health Medicine, Royal Australasian College of Physicians

2017-present Chair, Queensland Hepatitis C elimination working group.

2017-2023 Member, Communicable Diseases Intelligence Editorial Board.

2012-2016 Chair Western Australian Committee on Blood Borne Viruses and Sexually Transmitted infections

2011 - 2012 Member, Governance Committee, NSW HIV and STI Clinical Services Planning Project

2010 Member, Advisory Committee – Evaluation of the NSW HIV, Sexually Transmissible Infections and Hepatitis C Strategies and the supporting implementation plan for Aboriginal People

2010 Vice-President Australian Federation of AIDS Organisations

2006 – 2009 Chair, Blood borne virus and STI Subcommittee, Australian Population Health Development Principal Committee

2001-2003 Chair, Intergovernmental Committee on AIDS, Hepatitis C and Related Diseases

1999-2003 Scientific Advisory Committee, National Centre for HIV Epidemiology and Clinical Research

1997-1999 Research Advisory Committee of the Australian National Council on AIDS and Related Diseases

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Research Grants awarded since 2013:

Over $2.93 million in grant money awarded since 2013

Riley T, Reid S, **Selvey LA**, Richards R, Collins D, Blackall P, Badstone D, Brain D. 2022 – 2025. A One Health/System Dynamics approach to reducing *Clostridioides difficile* infection. *NHMRC Ideas Grant*, $1,284,891.

Selvey Linda 2019-2021. Routine follow up of hepatitis C notifications to increase hepatitis C treatment uptake and evaluation of community-based hepatitis C interventions. *EC Australia, Burnet Institute* $212,000.

Selvey L, Osborne N, 2020. Investigation of the impacts of prolonged heat on health and wellbeing – a scoping review. *Queensland Health.* $24,000.

Mueller J, Toms L-M, Aylward L, ... **Selvey L** et al. Feasibility study for a national biomonitoring program. *Victorian Department of Human Services*. $49,322. (CIF)

Praske B, **Selvey LA**, 2018. My Health Record. Prison Health Test Bed Project. *Digital Health Agency. $261,500.*

Hall N, **Selvey LA,** Go-Sam C, 2018. Evaluation: safe and healthy drinking water in Indigenous local government areas. Pilot – Torres Strait Region (Phase 2). *Queensland Health.* $50,000.

Selvey LA, Riley T, Robson J, Stafford R, 2017. Risk factors for community-acquired *Clostridium difficile* infection in Queensland. A pilot study. *Queensland Alliance for Environmental Health Sciences.* $40,000

Guy, R, ... **Selvey LA....** Identifying and addressing gaps in Australia's HPV vaccination program. *NHMRC Partnership grant. $689,722.60 from 2016 – 2020 (CIE).*

Selvey LA, Lobo R, Hallett J. Evaluation of sexual health outcomes and well-being of sex workers in Western Australia. *Western Australian Department of Health. $100,000 for 2016*

Selvey LA, Burns, S. Formative research to inform the development of an intervention to increase the uptake of HPV vaccination via the school-based vaccination program. *Western Australian Department of Health. $38,987 for 2016.*

Lobo R, **Selvey LA**. Impact of a peer-based clinic for gay men on HIV and STI risk behaviours. *Western Australian AIDS Council. $15,000 for 2015*

Rumchev K, Mullins B, **Selvey LA**, Zhao Y, Bertolatti D, Miller V, Netto K, Jansz J, Hannelly T, Mead-Hunter R, Spickett J. Noise, dust and vibration exposure in agriculture *Safe Work Australia. $179,000 for 2014*

Mullins B, Bertolatti D, Rumchev K, **Selvey LA,** Hannelly T, Edwards P, Mead-Hunter R, Jansz J, Jian L. Welshpool Pilot ultrafine air particle study. *Dept of Environment and Conservation WA - $14,000 (for 2013)*

Publications – 108 publications in peer-reviewed journals. Publications since 2013 are included here. Relevant papers are highlighted in yellow:

Samuel Brookfield; **Linda Selvey;** Lisa Fitzgerald; Lisa Maher (2023). "More human": Using ethnographic insights to develop a posthuman framework of 'extended recovery' for harmful drug use. *SSM - Qualitative Research in Health.* doi: 10.1016/j.ssmqr.2023.100245

Lilly K, Kean B, Hallett J, Robinson S and **Selvey LA** (2023) Factors of the policy process influencing Health in All Policies in local government: A scoping review. *Front. Public Health* 11:1010335.doi: 10.3389/fpubh.2023.1010335

Belachew SA, Hall L, **Selvey LA** (2022) Magnitude of non-prescribed antibiotic dispensing in Ethiopia: a multicentre simulated client study with a focus on non-urban towns. *Journal of Antimicrobial Chemotherapy*, dkac341, https://doi.org/10.1093/jac/dkac341

Cribb DM, Varrone L, Wallace RL, ...**Selvey LA**,.... Kirk MD (2022) Risk factors for campylobacteriosis in Australia: outcomes of a 2018 – 2019 case control study. BMC Infectious Diseases 22(1), 586

Belachew SA, Hall L, **Selvey LA** (2022) Community drug retail outlet staff's knowledge, attitudes and practices towards non-prescription antibiotics use and antibiotic resistance in the Amhara region, Ethiopia with a focus on non-urban towns. Antimicrobial Resistance and Infection Control 11(1), 64

Vujovich-Dunn C, Wand H, Brotherton JML,.... **Selvey LA**.... Kaldor J (2022) Measuring school level attributable risk to support school-based HPV vaccination programs. BMC Public Health 22(1) 822

Brookfield S, **Selvey L**, Maher L, Fitzgerald L (2022) "Making ground": an ethnography of 'living with' harmful methamphetamine use and the plurality of recovery. Journal of Drug Issues 52(3), 366-388.

Puljevic C, Massi L, Brown R, Mills R, Turner L, Smirnov A, **Selvey LA.** (2022) Barriers and enablers to hepatitis C treatment among clients of Aboriginal Community Controlled Health Services in South East Queensland, Australia: a qualitative study. Australian Journal of Primary Health, *in press*, doi: 10.1071/PY21055

Vogt, F., Haire, B., **Selvey, L.,** Katelaris, A. L., & Kaldor, J. (2022). Effectiveness evaluation of digital contact tracing for COVID-19 in New South Wales, Australia. *The Lancet Public Health.* 7(3), pp. e250-e258. doi:10.1016/s2468-2667(22)00010-x

Strathearn, M., Osborne, N. J., & **Selvey, LA.** (2022). Impact of low-intensity heat events on mortality and morbidity in regions with hot, humid summers: a scoping literature review. *Int J Biometeorol.* 66(5), pp. 1013-1029. doi:10.1007/s00484-022-02243-z

Selvey LA, Carpenter M, Lazarou M, Cullerton K. (2022). Communicating about Energy Policy in a Resource-Rich Jurisdiction during the Climate Crisis: Lessons from the People of Brisbane, Queensland, Australia. IJERPH, 19(8),4635. doi: 10.3390/ijerph19084635

Brookfield, S., Fitzgerald, L., **Selvey, L.**, & Maher, L. (2021). "We're supposed to be a family here": An ethnography of preserving, achieving, and performing normality within methamphetamine recovery. *SSM Popul Health, 16*, 100969. doi:10.1016/j.ssmph.2021.100969

Sisnowski, J., Vujovich-Dunn, C., Gidding, H., Brotherton, J., Wand, H., Lorch, R.,..., **Selvey LA**,.... Guy, R. (2021). Differences in school factors associated with adolescent HPV vaccination initiation and completion coverage in three Australian states. *Vaccine, 39*(41), 6117-6126. doi:10.1016/j.vaccine.2021.08.076

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Moffat CRM, Kennedy KJ, O'Neill B, **Selvey L**, Kirk MD. 2021. Bacteraemia, antimicrobial susceptibility and treatment among *Campylobacter*-associated hospitalisations in the Australian Capital Territory: a review. BMC Infect Dis 21:848, https://doi.org/10.1186/s12879-021-06558-x

Belachew SA, Hall L, Erku DA, **Selvey LA**. 2021. No prescription? No problem: drivers of non-prescribed sale of antibiotics among community drug retail outlets in low and middle income conuntries: a systematic review of qualitative studies. BMC Public Health 21(1), 1056

Heard E, Smirnov A, Massi L, **Selvey LA.** How can general practitioners support people who inject drugs to engage with direct-acting antiviral treatment for HCV? A qualitative study. Australian Journal of General Practice. *In press*

Brookfield S, **Selvey L**, Maher L, Fitzgerald L, 2021. "There's no sense to it": A posthumanist enthnography of agency in methamphetamine recovery. Contemporary Drug Problems. DOI: 10.1177/00914509211031609, pp 1 – 21.

Selvey LA, Boyle FM, Dettrick Z, Ostini R, Eley DS, 2021. Sustainable rural physician training: leadership in a fragile environment. MJA Supplement Chapter 3. *MJA, 215 (1 Suppl), July 2021, doi:10.5694/mja2.51122*

Ostini R, McGrail MR, Kondalsamy-Chennakesavan S, Hill P, O'Sullivan B, **Selvey LA**, Eley DS, Adegbija O, Boyle FM, Dettrick Z, Jennaway M, Strasser S, 2021. Building a sustainable rural physician workforce. MJA, 215 (1 Suppl, July 2021, *doi:10.5694/mja2.51122*

Lobo E, McCausland K, Bates J, **Selvey L**, Jones J, Jeffreys E, Dean J, Fitzgerald L. Lessons learned from Australian case studies of sex workers engaged in academic research about sex worker health, wellbeing and structural impediments. *In* S Bell, P Aggleton & A Gibson,

2021. Peer Research in health and social development. International Perspectives on participatory research. Routledge Taylor & Francis group, Oxfordshire UK

Hall NL, Grodecki H, Jackson G, Go Sam C, Milligan B, Blake C, Veronese T, **Selvey L**. 2021. Drinking water delivery in the outer Torres Strait Islands: a case study addressing sustainable water issues in remote Indigenous communities. Australian Journal of Water Resources, 2021, 25(1): 80-89, doi: 10.1080/13241583.2021.1932280

Heard E, Smirnov A, Massi L, **Selvey LA.** Personal, provider and system-level barriers and enablers for hepatitis C treatment in the era of direct-acting antivirals: Experiences of patients who inject drugs accessing treatment in general practice settings in Australia. Journal of Substance Abuse Treatment, 2021, 127: 108460. https://doi.org/10.1016/j.jsat.2021.108460

Belachew, S. A., Hall, L., & **Selvey, L. A.** (2021). Non-prescription dispensing of antibiotic agents among community drug retail outlets in Sub-Saharan African countries: a systematic review and meta-analysis. *Antimicrob Resist Infect Control, 10*(1), 13. doi:10.1186/s13756-020-00880-w

Moffatt, C. R. M., Kennedy, K. J., **Selvey, L.,** & Kirk, M. D. (2021). Campylobacter-associated hospitalisations in an Australian provincial setting. *BMC Infect Dis, 21*(1), 10. doi:10.1186/s12879-020-05694-0

Burns, S., **Selvey, L.,** & Roux, F. (2020). Influences to HPV completion via a school-based immunisation program. *Sex Education*, 1-16. doi:10.1080/14681811.2020.1788527

Davey, T. M., & **Selvey, L. A.** (2020). Relationship between Land Use/Land-Use Change and Human Health in Australia: A Scoping Study. *Int J Environ Res Public Health, 17*(23). doi:10.3390/ijerph17238992

Leith Morris, **Linda Selvey**, Owain Williams, Charles Gilks & Andrew Smirnov (2020) Reasons for Not Seeking Hepatitis C Treatment among People Who Inject Drugs, Substance Use & Misuse, DOI: 10.1080/10826084.2020.1846198

Kahlia McCausland, Roanna Lobo, Mattea Lazarou, Jonathan Hallett, Julie Bates, Basil Donovan & **Linda A. Selvey** (2020) 'It is stigma that makes my work dangerous': experiences and consequences of disclosure, stigma and discrimination among sex workers in Western Australia, Culture, Health & Sexuality, DOI: 10.1080/13691058.2020.1825813

Lobo, Roanna, McCausland, Kahlia, Bates, Julie, Hallett, Jonathan, Donovan, Basil, and **Selvey, Linda A.** (2020). *Sex workers as peer researchers – a qualitative investigation of the benefits and challenges. Culture, Health and Sexuality* 1-16. https://doi.org/10.1080/13691058.2020.1787520

Varrone, Liana, Glass, Kathryn, Stafford, Russell J., Kirk, Martyn D., and **Selvey, Linda (2020).** *A meta-analysis of case-control studies examining sporadic campylobacteriosis in Australia and New Zealand from 1990 to 2016. Australian and New Zealand Journal of Public Health 44* (4) 1753-6405.12998 313-319. https://doi.org/10.1111/1753-6405.12998

Shrestha A, Mullins B, Zhao Y, **Selvey LA,** Rumchev K. Exposure to air pollutants among cyclists: a comparison of different cycling routes in Perth, Western Australia. Air Qual Atmos Health. 2020: 13, 1023–1034

Nepal A, Hendrie D, **Selvey LA**, Robinson S. Factors influencing the inappropriate use of antibiotics in the Rupandehi district of Nepal. Int J Health Plann Mgmt, 2020, 1-18. DOI: 10.1002/hpm.3061

Morris L, **Selvey L,** Williams O, Gilks C, Kvassy A, Smirnov A. Hepatitis C cascade of care at an integrated community facility for people who inject drugs. Journal of Substance Abuse Treatment, 2020, 114: 108025

Varrone L, Glass K, Stafford RJ, Kirk MD, **Selvey L**. Validation of questions designed for investigation of gastroenteritis. *Food Control,* 2020, 108:106871

Selvey LA, Roux F, Burns S. Potential process improvements to increase coverage of human papillomavirus vaccine in schools – A focus on schools with low vaccine uptake. *Vaccine* 2020, 38(14):2971-77. 10.1016/j.vaccine.2020.02.047

Nepal A, Hendrie D, Robinson S, **Selvey LA**. Analysis of patterns of antibiotic prescribing in public health facilities in Nepal. *The Journal of Infection in Developing Countries* 2020 14(01):18-27. doi: 10.3855/jidc.11817.

Brookfield S, Fitzgerald L, **Selvey L**, Maher L. Turning points, identity, and social capital: A meta-ethnography of methamphetamine recovery. *Int J Drug Policy* (2019) 67:79-90. doi: 10.1016/j.drugpo.2019.02.002.

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Lilly K, Hallett J, Robinson S, **Selvey LA.** Insights into local health and wellbeing policy process in Australia. *Health Promot Int* (2019). doi: 10.1093/heapro/daz082.

Minney-Smith CA, **Selvey LA**, Levy A, Smith DW. Post-pandemic influenza A/H1N1pdm09 is associated with more severe outcomes than A/H3N2 and other respiratory viruses in adult hospitalisations. *Epidemiol Infect* 2019 147:e310. doi: 10.1017/S095026881900195X.

Nepal A, Hendrie D, Robinson S, **Selvey LA.** Survey of the pattern of antibiotic dispensing in private pharmacies in Nepal. *BMJ Open* (2019) 9(10):e032422. doi: 10.1136/bmjopen-2019-032422.

Nepal A, Hendrie D, Robinson S, **Selvey LA.** Knowledge, attitudes and practices relating to antibiotic use among community members of the Rupandehi District in Nepal. *BMC Public Health,* 2019 19(1):1558. doi: 10.1186/s12889-019-7924-5.

Rumchev K, Gilbey S, Mead-Hunter R, **Selvey L,** Netto K, Mullins B. Agricultural Dust Exposures and Health and Safety Practices among Western Australian Wheatbelt Farmers during Harvest. *Int J Environ Res Public Health,* 2019 16(24). doi: 10.3390/ijerph16245009.

Selvey LA, McCausland K, Lobo R, Bates J, Donovan B, Hallett J. A snapshot of male sex worker health and wellbeing in Western Australia. *Sex Health* 2019, 16(3): 233-239. doi: 10.1071/SH18166.

Brookfield S, Fitzgerald L, **Selvey L**, Maher L. The Blind Men & the Elephant: Meta-Ethnography Thirty Years On. **Qualitative Health Research,** 2019, 29(11) 1674-81.

Mead-Hunter R, **Selvey LA,** Rumchev KB, Netto KJ, Mullins BJ. Noise Exposure on Mixed Grain and Livestock Farms in Western Australia. **Annals of work exposures and health.** 2019, 63(3), 305-15 doi: 10.1093/annweh/wxy105

Nicholls W, **Selvey L**, Harper C, Persson M, Robinson S. The psychosocial impact of cleft in a Western Australian cohort across three age groups. **Cleft Palate Craniofacial Journal,** 2019, 56(2):210-221. DOI: 10.1177/1055665618769660

Nicholls W, Persson M, Robinson S, **Selvey L.** Adult narratives of the psychosocial impact of cleft in a Western Australian cohort. **Cleft Palate Craniofacial Journal**, 2019, 56(3), 373-382. DOI: 10.1177/1055665618770184

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Walker LJ, **Selvey LA**, Jardine A, Johansen CA, Lindsay MDA, Mosquito and virus surveillance as a predictor of human Ross River virus infection in South-West Western Australia: How useful is it? **American Journal of Tropical Medicine and Hygiene**, 2018, 99(4):1066-73.

Gilbey SE, **Selvey LA**, Mead-Hunter R, Mullins B, Netto K, Zhao Y & Rumchev KB Occupational exposures to agricultural dust by Western Australian wheat-belt farmers during seeding operations, **Journal of Occupational and Environmental Hygiene**, 2018, DOI: 10.1080/15459624.2018.1521973

Selvey LA, Lobo, RC, McCausland KL, Donovan B, Bates J, Hallett J. Challenges Facing Asian Sex Workers in Western Australia: Implications for Health Promotion and Support Services. ***Frontiers in Public Health,*** 2018, doi: https://doi.org/10.3389/fpubh.2018.00171

Selvey LA, Hall R, Would a good screening test increase the effectiveness of border screening for influenza control? ***Clinical Microbiology and Infection,*** 2018, 24(3):214-215. doi:10.1016/j.cmi.2017.12.006

Nicholls W, Harper C, Robinson S, Persson M, **Selvey L.** Adult specific life outcomes of cleft lip and palate in a Western Australian cohort. **Cleft Palate Craniofacial Journal,** 2018, 55:1419-1429. DOI: 10.1177/1055665618768540

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24 February 2023

PRIVILEGED AND CONFIDENTIAL

Professor Linda Selvey

By email: [redacted]

Dear Professor Selvey,

Pabai & Anor v Commonwealth of Australia (VID622/2021) (Proceeding)

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1. Letter of Instruction

1.1. We refer to our letter of retainer dated 19 September 2022 (**Retainer Letter**) and confirm that you are retained by Uncle Pabai Pabai and Uncle Paul Kabai (**Applicants**) to act as an independent expert in the matter of *Pabai & Anor v Commonwealth of Australia*, VID622/2021 (**Climate Class Action**).

1.2. We confirm that the confidentiality obligations in respect of documents and information provided to you for the purpose of this engagement are governed by the terms of the Retainer Letter and Deed of Confidentiality dated 19 September 2022.

1.3. We also remind you of the roles and duties of expert witnesses as set out in the Retainer Letter and ask that you refer to them as you prepare your expert report(s) in this proceeding. In particular, please take some time to reacquaint yourself with the following documents, which we provided to you with our original letter:

(a) the Federal Court of Australia Expert Evidence Practice Note (**GPN-EXPT**), including the Harmonised Expert Witness Code of Conduct (the **Code**) at Annexure A of that Practice Note and the Concurrent Expert Evidence Guidelines (the **Guidelines**) at Annexure B (collectively, the **Practice Note**); and

(b) Rule 23.13 of the *Federal Court Rules 2011* (Cth).

1.4. The purpose of this letter is to request that you prepare a written report, providing your independent expert opinion, in response to the questions set out in Annexure C to this letter.

1.5. In providing your independent expert opinion in answer to the questions, please have regard to the Assumptions set out in Annexure B. For the purposes of providing your opinion you are instructed to assume that the information contained in Annexure B is correct.

1.6. Should you in your report make any assumptions in addition to those set out in Annexure B, please state what those additional assumptions are.

1.7. In order to ensure your report is clearly set out, we ask that you please:

a) provide a brief summary at the beginning of the report;

b) use numbered paragraphs, page numbers and headings where appropriate;

c) provide citations to documents where appropriate; and

d) provide citations to any literature or other materials referred to or relied upon by you in support of your opinions, and a bibliography if necessary.

1.8. Please annex to your report:

a) a detailed curriculum vitae, setting out the training, study and experience that establishes your expertise in relation to the issues raised by these instructions; and

b) this Letter of Instruction and the Letter of Engagement.

1.9. At the end of your report, please sign the report and include a declaration to the following effect:

I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance that I regard as relevant have, to my knowledge, been withheld from the Court.

2. Materials

2.1. Set out at Annexure A is an index of the documents provided to you.

2.2. The pleadings have been provided to you so that you are aware of the allegations made and positions taken by each party. Unless an allegation is admitted, the facts are in dispute.

2.3. We have also provided to you the optional materials referred to in B1 to B8 of Annexure A. These materials are provided by way of assistance. You may use or ignore these documents as you consider appropriate. You are instructed to review these documents and form your own views on them.

2.4. Set out at Annexure D is an outline of the optional materials referred to in B1 to B8 of Annexure A. The Annexure D outline is merely a tool to assist your review and should not replace your independent reading of the materials.

2.5. If you consider that you require any additional information or materials in order to complete your work, please contact us and we will endeavour to provide that additional information and materials.

3. Your Opinion

3.1. We request that you provide a written report addressing the questions set out in Annexure C to this letter.

3.2. In answering the Annexure C questions, please provide detailed reasons for your opinions, including the facts or assumptions that affect your reasoning and conclusions, with specific reference to any material on which you rely in reaching your conclusions.

4. Preparation of Your Report

4.1. We would be grateful if you would set out the answers to the questions at Annexure C in a written report, having regard to the requirements set out in the Federal Court of Australia Expert Evidence Practice Note.

4.2. After you have had the opportunity to consider the questions at Annexure C, as well as the materials listed in Annexure A (outlined in Annexure D) and the Assumptions in Annexure B, we would be grateful if you could advise of any information or material not currently provided to you which you require to respond to any of the Annexure C questions.

4.3. You are requested to complete your report by 31 March 2023.

If you have any questions or if you require any clarification of the facts, assumptions or questions set out in this letter and its annexures, please do not hesitate contact me [redacted].

Yours faithfully,

Brett Spiegel
Principal Lawyer
Phi Finney McDonald

Encl.

ANNEXURE A

INDEX OF MATERIALS

Tab No.	Date	Description of document(s)
A	**PLEADINGS**	
A1.	31 March 2022	Applicants' Concise Statement
A2.	14 April 2022	Respondent's Concise Statement
A3.	21 September 2022	Defence to Amended Statement of Claim
A4.	7 October 2022	Amended Originating Application
A5.	3 February 2022	Further Amended Statement of Claim
B	**OPTIONAL MATERIALS**	
B1.	Tagai State College, *Your Guide to Living in the Torres Strait* (Internal Memorandum, 13 May 2022)	
B2.	Australian Bureau of Statistics, *Torres Strait Island – 2021 Census All Persons QuickStats* (Web Page, accessed 14 February 2022)	
B3.	Torres and Cape Hospital and Health Service, *Health Equity Strategy Presentation 2022-2025* (Powerpoint Presentation, December 2022)	
B4.	Torres and Cape Hospital and Health Service, *Local Area Needs Assessment* (Summary Report, December 2022)	
B5.	BMT Global for the Torres Strait Regional Authority, *Torres Strait Climate Change and Health–First Pass Risk Assessment* (Final Report, 2018)	
B6.	Torres Strait Island Regional Council, *Torres Strait Disaster Management Plan 2020* (Report, 16 September 2020)	
B7.	Torres Strait Island Regional Council, *Drinking Water Quality Management Plan* (Annual Report, 22 December 2021)	
B8.	Cara Beal, Bernard Dorante, Patrick Pearson, Safaa Aldirawi and Noora Abdallah, 'Working with Community and Council: The Kirirri Story' (2020) 5 *Water e-Journal*, 1-15	

ANNEXURE B

Assumptions

In answering the questions in Annexure C below, please make the following assumptions (insofar as they are relevant to your answers):

A. The increase in global average surface temperature is presently 1.2°C (defined by decadal average) (**Current Warming Level**) above pre-industrial levels (**Baseline**).

B. The global average surface temperature above Baseline will increase beyond the Current Warming Level.

C. There is a causal relationship between increased global average surface temperature and the following impacts on the Torres Strait:

   a. increased average surface temperature;

   b. increased humidity and wet bulb temperature;

   c. increased variability of rainfall;

   d. increased frequency and severity of extreme weather events, including heatwaves, storm surges and inundation;

   e. increased sea level rise;

   f. decreased availability and quality of drinking water;

   g. decreased availability and quality of traditional sources of food, including turtles, dugongs, and traditionally planted crops.

   (Torres Strait Impacts)

ANNEXURE C

Questions

In your report, please answer the following questions and explain your reasons for your answers.

References to Torres Strait Islanders are to persons who are of Torres Strait Islander descent who live on the Torres Strait Islands. If an answer does not apply only to persons within this description and/or does not apply to all persons within this description, please state the limitation on your answer and identify the persons to whom your answer applies. For example, please state whether an answer differs by age group, gender, or physical location.

<u>Basis of expertise</u>

Q.1 Please describe your academic qualifications and professional background, your experience in the field of climate change impacts on health (including, in particular, in the Torres Strait) and any other training, study or experience that is relevant to your answering the questions in this Annexure C. You may wish to do so by reference to a current curriculum vitae.

<u>Health of Torres Strait Islanders</u>

Q.2 Provide an overview of health and health-related data for Torres Strait Islanders. Without limiting the factors you consider relevant, include data on life expectancy, prevalence and incidence of disease, and factors that affect health outcomes of Torres Strait Islanders.

<u>Effects of climate change on the health of Torres Strait Islanders</u>

Q.3 What, if any, are the current and future effects on the health of Torres Strait Islanders arising from the Torres Strait Impacts?

In your answer, please identify and describe any current and likely future:

1. **direct impacts** on the human body; and

2. **indirect impacts** on human health,

of Torres Strait Islanders that arise from the Torres Strait Impacts.

In answering this question, state whether the nature, extent or likelihood of those impacts differs as global average surface temperature increases.

<u>Vulnerability of Torres Strait Islanders</u>

Q.4 Are Torres Strait Islanders more vulnerable to the effects on human health you identified in response to Q.3 of the Torres Strait Impacts, as compared to the general Australian population? If your answer is yes, explain why and in what respects.

Adaptation

Q.5 What measures, if any, would be required to be implemented to mitigate the health effects on Torres Strait Islanders described in your answer to Q.3?

ANNEXURE D

OUTLINE OF OPTIONAL MATERIALS

1.1. This annexure outlines the contents of materials identified in B1 to B8 of Annexure A to your Letter of Instruction. This annexure is merely a tool and should not replace your independent reading of the source materials.

1.2. As stated in your Letter of Instruction, you should review the source materials and form your own views on them. You may use or ignore these documents as you consider appropriate. The provision of these materials does not limit in any way the materials to which you consider you should have regard, or the research you consider you should undertake, in order to provide your opinion in response to the questions in Annexure C.

2. Item B1: *Tagai State College: Your Guide to Living in the Torres Strait* (13 May 2022)

General services

2.1. Badu:

(a) airstrip;
(b) health centre with a permanent doctor;
(c) two grocery stores;
(d) post office;
(e) sporting facilities;
(f) childcare services;
(g) television reception;
(h) mobile coverage; and
(i) internet access.[1]

2.2. Dauan:

(a) helipad;
(b) health centre with a permanent nurse;
(c) fortnightly visits by a General Practitioner;
(d) two grocery stores;
(e) water plant reservoirs/filtration collection wells;
(f) power station;
(g) barge ramp;
(h) pier for small craft; and
(i) television reception.[2]
(j) There is no airstrip on Dauan.[3] The island is only accessible by boat or helicopter. In addition, mobile coverage and internet access is limited.[4]

2.3. Erub:

(a) airstrip;
(b) health centre with a permanent nurse;
(c) fortnightly visits by a General Practitioner;

[1] Tagai State College, *Your Guide to Living in the Torres Strait* (Internal Memorandum, 13 May 2022),10.
[2] Ibid.
[3] Ibid.
[4] Ibid.

(d) IBIS grocery store;
(e) power station;
(f) barge ramp for small craft; and
(g) television reception.[5]
(h) There is limited mobile coverage and internet access on Erub.[6]

2.4. Iama:

(a) airstrip;
(b) health centre with a nurse;
(c) fortnightly visits by a General Practitioner;
(d) IBIS grocery store;
(e) barge ramp;
(f) pier for small craft;
(g) State Emergency Service shed;
(h) television reception;
(i) mobile coverage;
(j) internet access.[7]

2.5. Saibai:

(a) airstrip;
(b) health centre with nurses;
(c) fortnightly visits by a General Practitioner;
(d) IBIS grocery store;
(e) State Emergency Service shed;
(f) barge ramp;
(g) pier for small craft;
(h) community centre;
(i) television reception; and
(j) mobile coverage;
(k) internet access.[8]
(l) Saibai is subject to flooding and rising sea levels and that the wet season deposits approximately 2 metres of rain.[9] The dry season, in contrast, causes water shortages.[10]

2.6. Moa (Kubin community):

(a) airstrip;
(b) health centre with a permanent nurse;
(c) fortnightly visits by a General Practitioner;
(d) IBIS grocery store;
(e) State Emergency Service shed;
(f) power station;
(g) barge ramp;
(h) pier for small craft;
(i) television reception;
(j) mobile coverage;

[5] Ibid 11.
[6] Ibid.
[7] Ibid.
[8] Ibid.
[9] Ibid.
[10] Ibid.

(k) internet access.[11]

2.7. Moa (St Paul's community):

(a) charter bus service to Kubin airstrip;
(b) helipad with direct flights to Horn Island;
(c) health centre;
(d) fortnightly visits by a General Practitioner;
(e) IBIS grocery store;
(f) power station;
(g) barge ramp;
(h) pier;
(i) television reception; and
(j) internet access.[12]

2.8. Mabuiag:

(a) airstrip;
(b) health centre with a permanent nurse;
(c) fortnightly visits by a General Practitioner;
(d) IBIS grocery store;
(e) community police;
(f) power station;
(g) barge ramp;
(h) pier for small craft;
(i) television reception;
(j) mobile coverage;
(k) internet access.[13]

2.9. Boigu:

(a) airstrip;
(b) health centre with a permanent nurse;
(c) fortnightly visits by a General Practitioner;
(d) IBIS grocery store;
(e) power station;
(f) barge ramp;
(g) pier for small craft;
(h) television reception;
(i) mobile coverage; and
(j) internet access.[14]
(k) Boigu is subject to flooding and is very susceptible to the predicted sea level rises from the greenhouse effect.[15]

2.10. Masig:

(a) airstrip;
(b) health centre with two permanent nurses;

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[11] Ibid 12.
[12] Ibid 14.
[13] Ibid 12.
[14] Ibid.
[15] Ibid.

(c) fortnightly visits by a General Practitioner;
(d) three grocery stores (IBIS and two mini-marts);
(e) post office;
(f) State Emergency Service shed;
(g) power station;
(h) barge ramp;
(i) pier for small craft;
(j) television reception;
(k) mobile coverage; and
(l) internet access.[16]

2.11. Mer:

(a) airstrip;
(b) health centre with nurses;
(c) fortnightly visits by a General Practitioner;
(d) IBIS grocery store;
(e) power station;
(f) barge ramp;
(g) television reception;
(h) mobile coverage; and
(i) internet access.[17]

2.12. Horn Island:

(a) airport, including daily flights from Cairns and the outer Torres Strait;
(b) two grocery stores;
(c) fire/State Emergency Service station;
(d) health centre with a nurse;
(e) weekly visits by a General Practitioner;
(f) television reception;
(g) mobile coverage; and
(h) regular daily ferry services to Thursday Island.[18]

2.13. Poruma:

(a) airstrip;
(b) health centre with a permanent nurse;
(c) fortnightly visits by a General Practitioner;
(d) two grocery stores;
(e) State Emergency Service shed;
(f) Ergon power station;
(g) barge ramp;
(h) small pier;
(i) seafood factory;
(j) television reception;
(k) mobile coverage (limited); and
(l) internet access (limited).[19]

[16] Ibid 13.
[17] Ibid.
[18] Ibid.
[19] Ibid 14.

2.14. Ugar:

(a) helipad;
(b) barge ramp;
(c) pier for small craft;
(d) IBIS store;
(e) health centre;
(f) fortnightly visits by a General Practitioner;
(g) Telstra phone tower;
(h) Ergon power facility;
(i) television reception; and
(j) limited internet access.[20]

2.15. Warraber:

(a) airport;
(b) health centre;
(c) IBIS grocery store;
(d) power station;
(e) barge ramp; and
(f) limited mobile coverage.[21]

2.16. Thursday Island:

(a) ferry services;
(b) health centre;
(c) hospital;
(d) childcare services;
(e) dentist;
(f) pharmacy;
(g) post office;
(h) police station;
(i) ambulance station;
(j) fire/State Emergency Service station;
(k) grocery stores;
(l) takeaway stores;
(m) petrol stations;
(n) restaurants;
(o) cafes;
(p) butcher;
(q) bakery;
(r) television reception;
(s) mobile coverage; and
(t) internet access.[22]

<u>Health services</u>

2.17. Thursday Island:

[20] Ibid.
[21] Ibid 15.
[22] Ibid.

(a) the hospital on Thursday Island has 38 beds and an after-hours emergency department;
(b) serious cases are transported by the Royal Flying Doctor Service to Cairns; and
(c) basic medical, pharmaceutical, physiotherapy, podiatry and dental appointments are serviced by the health centre, pharmacy and dentist.[23]

2.18. Outer islands:

(a) all outer islands have a health centre staffed by a registered nurse or community health worker that deal with minor injuries and prescription medicines (which are ordered from Thursday Island);
(b) residents can schedule General Practitioner, podiatrist and nutritionist appointments every 3 – 4 weeks;
(c) for certain medical conditions, a doctor can approve patient travel to Thursday Island, Cairns or Brisbane and Queensland Health will cover the expense;
(d) in case of a medical emergency, a doctor can request immediate transportation by helicopter to Thursday Island.[24]

<u>Transportation</u>

2.19. The cost of fuel varies between communities:

(a) Thursday Island offers the cheapest fuel ($2 p/l of unleaded petrol at the time of publication);
(b) on outer islands, prices can be 50% more expensive.[25]

2.20. Most Torres Strait Island communities can only be accessed by plane or boat.[26] Most destinations are accessible through regular flights by Skytrans.[27] Thursday Island, Dauan and Ugar are only accessible by boat or helicopter.[28]

2.21. All flights to and from the Torres Strait go through Horn Island Airport.[29] Qantaslink Airlines flies direct from Cairns to Horn Island.[30]

2.22. There are two bus-ferry-bus services connecting Horn Island Airport and Thursday Island.[31]

<u>Electricity supply</u>

2.23. On Thursday Island and Horn Island, electricity is provided by Ergon Energy.[32]

2.24. On outer islands, electricity is paid for via a prepaid power card which is inserted into the meter box at a residence.[33]

3. Item B2: *Australian Bureau of Statistics: 2021 Census data, Torres Strait Island Local Government Area* (accessed 14 February 2022)

[23] Ibid 19.
[24] Ibid.
[25] Ibid 24.
[26] Ibid 25.
[27] Ibid.
[28] Ibid.
[29] Ibid.
[30] Ibid.
[31] Ibid 26.
[32] Ibid 34.
[33] Ibid.

Employment status and income[34]

3.1.

Residents in Torres Strait Local Government Area	**4,124**
Residents in Torres Strait Local Government Area with Torres Strait Islander ancestry	**3,577 (86.7%)**
Median weekly household income	$976.00
Median weekly personal income	$41.00
Median weekly family income	$923.00
In the labour force	1,152 (41.1%)
Not in the labour force	1,465 (52.3%)
Not stated whether in the labour force or not	182 (6.5%)
Working full-time	544 (47.2%)
Working part-time	368 (31.9%)
Away from work	104 (9.0%)
Unemployed	135 (11.7%)

4. **Item B3: *Torres and Cape Hospital and Health Service – Health Equity Strategy Presentation 2022-2025* (December 2022)**

Employment and income

4.1. In 2023, the unemployment rate for Aboriginal and Torres Strait Islander people living in the Torres and Cape Hospital and Health Service area was 23.2%.[35]

4.2. In 2022, 85% of the total population in the Torres and Cape Hospital and Health Service area had the poorest socioeconomic measures per the SEIFA index.[36]

Housing

4.3. 18.8% of Aboriginal and/or Torres Strait Islander people in Queensland live in crowded housing. In the Torres and Cape Hospital and Health Service area, more than 1 in 3 Aboriginal and/or Torres Strait Islander people live in crowded housing.[37]

Healthcare

4.4. Utilisation of Aboriginal and Torres Strait Islander Health Checks (Medicare Benefits Scheme codes) are lower than the state rate at 23.8 services for every 100 people compared to 37.3 services per 100 people for Queensland.[38]

[34] Australian Bureau of Statistic, 2021 Census data information, Torres Strait Island Local Government Area (LGA36960) available at https://www.abs.gov.au/census/find-census-data/quickstats/2021/LGA36960.
[35] Torres and Cape Hospital and Health Service, Health Equity Strategy Presentation 2022-2025 (Powerpoint Presentation, December 2022), 10.
[36] Ibid.
[37] Ibid.
[38] Ibid 12.

5. **Item B4: *Torres and Cape Hospital and Health Service – Local Area Needs Assessment* (Summary Report December 2022)**

Transport and healthcare

5.1. Servicing communities requires significant travel which is often difficult or impossible during the wet season (November to March).[39]

5.2. There are barriers to health care access including limited travel and accommodation options and cost constraints for individuals seeking assistance beyond their local service.[40]

6. **Item B5: *Torres Strait Regional Authority – Torres Strait Climate Change and Health: First Pass Risk Assessment* (2018)**

Electricity[41]

6.1. "Generators are known to fail on a regular basis when in use with implications for food quality and availability of vaccines."

6.2. "Vaccine loss is a common occurrence [due to generators failing on a regular basis]."

6.3. "Loss of lighting in health facilities impacts night work and results in a loss of communication (i.e. no ability to charge phones and contact health system when in need)."

Water[42]

6.4. "Water is a limited resource on most communities."

6.5. "Many islanders and health centres use bottled water."

6.6. "Aging water infrastructure and challenges with infrastructure maintenance often results in the need to boil water prior to use and daily water restrictions on outer islands is common."

Housing

6.7. "Some islands have little space for housing (i.e. little land for additional dwellings to be built) and existing houses are overcrowded by national standards."[43]

7. **Item B6: *Torres Strait Island Regional Council – Torres Strait Disaster Management Plan 2020***

Electricity

7.1. In relation to Thursday Island and Horn Island:

(a) electricity is generated by Ergon Energy via isolated power stations on each island and distributed by an isolated network;

[39] Torres Cape Hospital and Health Service, *Local Area Needs Assessment Summary Report*, December 2022, 15.
[40] Ibid.
[41] BMT Global for the Torres Strait Regional Authority, *Torres Strait Climate Change and Health–First Pass Risk Assessment* (Final Report, 2018), 34.
[42] Ibid.
[43] Ibid 19.

(b) generation occurs at automated power stations at various voltages;
(c) fuel storage capacity for each power station used to ensure reliable supply;
(d) Thursday Island has a minimum fuel stock level of 30 days and a storage capacity of 43 days; and
(e) Horn Island has a minimum fuel stock level of 30 days and a storage capacity of 78 days.[44]

7.2. In relation other islands in the Torres Strait:

(a) Ergon Energy generates and distributes electricity via a reticulation network in all communities;
(b) generation is by means of diesel-powered generators;
(c) individual power supply is accessed by pre-paid electricity meter cards, which presents issues in times of extended isolation if households cannot purchase power cards;
(d) Ergon Energy maintains enough diesel fuel on each island to maintain generation capacity for 78 summer days without re-supply; and
(e) there are limited backup generators to maintain services in times of power loss, which may impact the Council's ability to chlorinate the water supply and ensure sewage pump stations remain operational.[45]

8. Item B7: *Torres Strait Island Regional Council – Drinking Water Quality Management Plan: Annual Report 2020-2021* (22 December 2021)

8.1. In the 2020/2021 period, there were four cases of E. Coli reported in water on Moa, Erub and Mer.[46]

8.2. Drinking water schemes in operation on the islands serviced by TSIRC:[47]

Scheme Name	Population Served	Connections	Catchment Characteristics	Treatment Process
01 – Boigu	271	93	3 x Desalination Units Lagoon (rainfall)	Clarifier Media Filtration RO Desalination Chlorine Disinfection
02 – Dauan	191	63	4 x Wells Lagoon (rainfall)	Media Filtration Chlorine Disinfection
03 – Saibai	465	109	Lagoon (rainfall) 1 x Desalination Unit (mobile)	Media Filtration Chlorine Disinfection Bag Filtration
04 – Mabuiag	210	53	Lagoon (rainfall)	Media Filtration Chlorine Disinfection
05- Badu	813	234	3 x Wells (Ground water)	Coagulation (Alum) Media and Ultra Filtration pH adjustment Chlorine Disinfection
06 – Kubin	187	92	1 x Well 1 x Weir	Media Filtration Chlorine Disinfection

[44] TSIRC, Torres Strait Disaster Management Plan 2020, 20-21.
[45] Ibid 28.
[46] Torres Strait Island Regional Council, *Drinking Water Quality Management Plan* (Annual Report, 22 December 2021), 30.
[47] Ibid 5-6.

			1 x Lagoon (rainfall)	
07 – St Paul's	248	107	3 x Wells 1 x Weir 1 x Desalination Unit (mobile)	Media Filtration Chlorine Disinfection
08 – Kirriri	268	80	1 x Well Torres Shire Council Water Supply	Ultra-filtration by Torres Shire Council Media Filtration Chlorine Disinfection Bag filtration
09 -Iama	319	101	2 x Desalination Units 1 x Desalination Unit (mobile)	Settling Tank Media Filtration RO Desalination
10- Warraber	245	80	Lagoon (rainfall) 1 x Desalination Unit 1 x Desalination Unit (mobile)	Media Filtration Chlorine Disinfection
11 – Poruma	167	82	1 x Desalination Unit 1 x Desalination Unit (mobile) Lagoon (rainfall)	Settling Tank Media Filtration RO Desalination
12 – Masig	270	109	1 x Desalination Unit 1 x Desalination Unit (mobile) Lagoon (rainfall)	Settling Tank Media Filtration RO Desalination Chlorine Disinfection
13 – Ugar	85	36	2 x Wells Lagoon (rainfall)	Media Filtration Chlorine Disinfection
14 – Erub	328	126	1 x well Lagoon (rainfall) 1 x Desalination Unit (mobile)	Media and Ultra Filtration Chlorine Disinfection
15-Mer	453	137	3 x Desalination Units Lagoon (rainfall)	Settling tank Media filtration RO Desalination Bag filtration
Note: mobile desalination units are listed in the location they were set up on 30 June 2021				

9. **Item B8: C Beal et al., *Working with Community and Council: The Kirirri Story* (2020)**

9.1. "In many Torres Strait Islander communities, there are severe water restrictions during the dry season (May to November) and this can result in the treated, piped water supply being physically turned off by the council for up to 16 hours a day (i.e. controlled access to the mains water supply). Town or mains water may be available between the hours of 6-9am, 12-2pm and 6-10pm (these times will vary throughout the year)."[48]

[48] Beal, Cara & Dorante, Bernard & Pearson, Patrick & Aldirawi, Safaa & Abdallah, Noora. (2020). Working with Community and Council: The Kirirri Story. Water e-Journal. 5. 1-15. 10.21139/wej.2020.023. pg. 1.