

# Managing health impacts of heat in South East Queensland, Australia

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Heatwaves kill more people than any other natural hazard in Australia. Current literature on managing health risks of heatwaves highlights the importance of implementing urban planning measures, and engaging with vulnerable groups on a local level to better understand perceptions of risk and tailor health protection measures. This paper reviews arrangements to reduce heatwave health risks in South East Queensland in response to these themes. A literature search and document analysis, stakeholder interviews, and multi-stakeholder cross-sectoral workshops revealed that although heatwave management is not always considered by local government and disaster management stakeholders, many urban planning measures to minimize urban heat have been pursued. However, greater information from vulnerable groups is still needed to better inform heatwave management measures.

## Introduction

Heatwaves have been associated with increased morbidity, mortality and hospital admissions in many metropolitan regions globally, including the South East Queensland region (SEQ) in Australia.<sup>1–5</sup> Climate change is projected to increase the frequency and severity of heatwave events in SEQ, along with an increase in mean and maximum temperatures.<sup>6,7</sup> This could have critical implications for human settlements in the region as urban areas are especially sensitive to heatwave events because of the urban heat island effect (UHIE),<sup>8,a</sup> thereby exacerbating heat exposure for urban residents.<sup>9</sup>

This paper contributes to inform multi-scale heatwave management efforts by focusing on the example of SEQ. It draws on the findings of the Human Settlements component of the South East Queensland Climate Adaptation Research Initiative (SEQCARI), a 3-year integrated multi-sectoral study of climate change adaptation options for human settlements in SEQ, including urban planning and management, coastal management, physical infrastructure, emergency management and human health. To this end, the paper is structured in 3 parts. The first part presents the SEQCARI research approach followed by a literature review on heatwave management broadly. The second part presents background information on SEQ and investigates cross-sectoral ambivalences to heatwave management and risks based on document analysis, literature review and empirical data derived from stakeholder workshops and interviews. The paper concludes by providing insights that can inform the development of heat management measures under a changing climate.

## Research Approach

The Human Settlements component of SEQCARI aimed to explore and develop a range of appropriate adaptation strategies, policies and practices in each sector and across sectors, for better governance and management in response to the impacts of climate change. The research project was specifically directed to the SEQ region due to the earlier recognition of this region as one of 6 climate change ‘vulnerability hotspots’ in Australia.<sup>10</sup> The region is particularly vulnerable because of its coastal location and the distribution and location of its rapidly growing population. The project adopted a case study approach<sup>11</sup> that took both a systems view of the whole region and focused on key sectors within the SEQ region, including human health as well as urban planning and management, emergency management, physical infrastructure and coastal management.

Data collection involved cross-sectoral workshops and interviews as well as document analysis and literature review. Two series of workshops were carried out in 2010 and 2011 with stakeholders from state government agencies, non-government organizations (NGOs) and local government working in the sectors of human health, emergency management, urban planning and management, physical infrastructure and coastal management. These workshops generated stakeholder input on preliminary climate adaptation options developed by the SEQCARI team, including adaptation options relating to heatwave management. A total of forty-two stakeholders participated in these workshops.

A total of 30 interviews were carried out with state government representatives, representatives from 4 local governments

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and NGOs (see **Table 1** for a list of stakeholders representing different sectors which participated in interviews) during 2011. Interview questions related to climate change adaptation in the SEQ region, including impacts and priorities, factors affecting policy development for climate adaptation, barriers to effective action, opportunities for capacity building and integration of climate adaptation actions into other policy objectives. Interview content was analyzed using NVivo software with a specific focus on references to heatwaves and hot weather. Based on this analysis, this paper is specifically informed by 6 interviews with stakeholders working in the human health sector as well as 4 interviews with stakeholders engaged in urban planning and management, emergency management and coastal management.

In parallel, a document analysis and literature review was undertaken to identify merits and limitations in heatwave management plans globally, and investigate the nature of extreme heatwaves, health impacts and heatwave management in the SEQ region. This included an examination of refereed journal articles, urban planning reports, and regionally based disaster management plans.

## Heatwave Management

The impact of UHIE can be managed through a number of planning measures that often also benefit other urban policy goals such as air quality and energy usage.<sup>12,13</sup> Nevertheless, a raft of other adaptation measures will be needed to deal with increased risk of heat-related events and subsequent morbidity and mortality due to climate change.<sup>9,14</sup> These measures should be focused on increasing adaptive capacity of groups and individuals that are more vulnerable to heat-related morbidity and mortality, determined by social and community factors, as well as people's physiological characteristics.<sup>15</sup> Such vulnerable groups include the elderly (particularly women), persons with chronic conditions and/or disabilities, persons in heat-exposed living conditions, the socially isolated, people living in culturally and linguistically diverse communities, and people engaged in strenuous physical activity outdoors.<sup>16-19</sup> Risk factors may also include housing characteristics, socioeconomic conditions or environmental impacts such as UHIEs.<sup>18,20</sup>

To address increased risk of heatwave events, a number of cities globally have developed heatwave management plans and other adaptation measures to reduce associated health risks.<sup>21</sup> This is also the case of health authorities, local governments and NGOs in Australia.

Heatwave management plans have several desired features as shown in **Table 2**. These features may comprise strategies aimed

at supporting vulnerable groups. These include, but are not limited to, early warning systems, hotlines providing heat-related health information, ensuring organizations working with vulnerable groups have protocols and plans in place to manage risks during a heatwave and providing outreach to homeless people.<sup>2,22-28</sup> These strategies support measures taken by individuals and communities to manage health impacts of heat such as drinking plenty of water, minimizing physical activity, checking on vulnerable family members or friends, spending time in cool spaces such as shopping centers or cinemas, planning activities so to avoid being outdoors during the hottest parts of the day, taking cool showers or baths, and keeping homes as cool as possible.<sup>26</sup>

Moreover, local governments can target community-level intervention, including awareness campaigns reinforcing messages set out by state governments and NGOs, distribute health information in different languages and assist in the identification of local risks that can guide the development of local plans.<sup>27</sup> Additionally, local governments can also provide important information related to infrastructure that can assist in tailoring heatwave response plans at the local scale to avoid disruption in services provision during heatwave events, particularly electricity and public transport.<sup>27</sup>

However, while there are many benefits associated with heatwave management plans as above-mentioned, managing heatwave impacts is not simple and there are challenges concerning the development and implementation of heatwave management measures as shown in **Table 2**. For example, the development and implementation of heatwave management plans are confronted by limited information regarding vulnerable groups, competing issues, and ambivalence from the public and urban institutions.<sup>15,19,29</sup> Additionally, perceptions of heatwave risks often differ across policy makers and cultural and demographic groups.<sup>22,30</sup> Those that are more vulnerable or at risk might not necessarily see themselves as such.<sup>31</sup> As a result, developments in heatwave management have pointed to benefits of engaging with vulnerable groups and/or communities on a local level to better understand their perceptions of risk and tailor health protection measures.<sup>15,22,26,31</sup> In particular, individuals from vulnerable groups (defined through common social and/or geographical interests/characteristics) can take an active role in researching needs and assessing hazards and their capacities.<sup>32,33</sup>

## Background – The SEQ Context

The SEQ region encompasses 11 local authorities (see **Fig. 1**), which covers an area of approximately 2.2 million hectares. Over

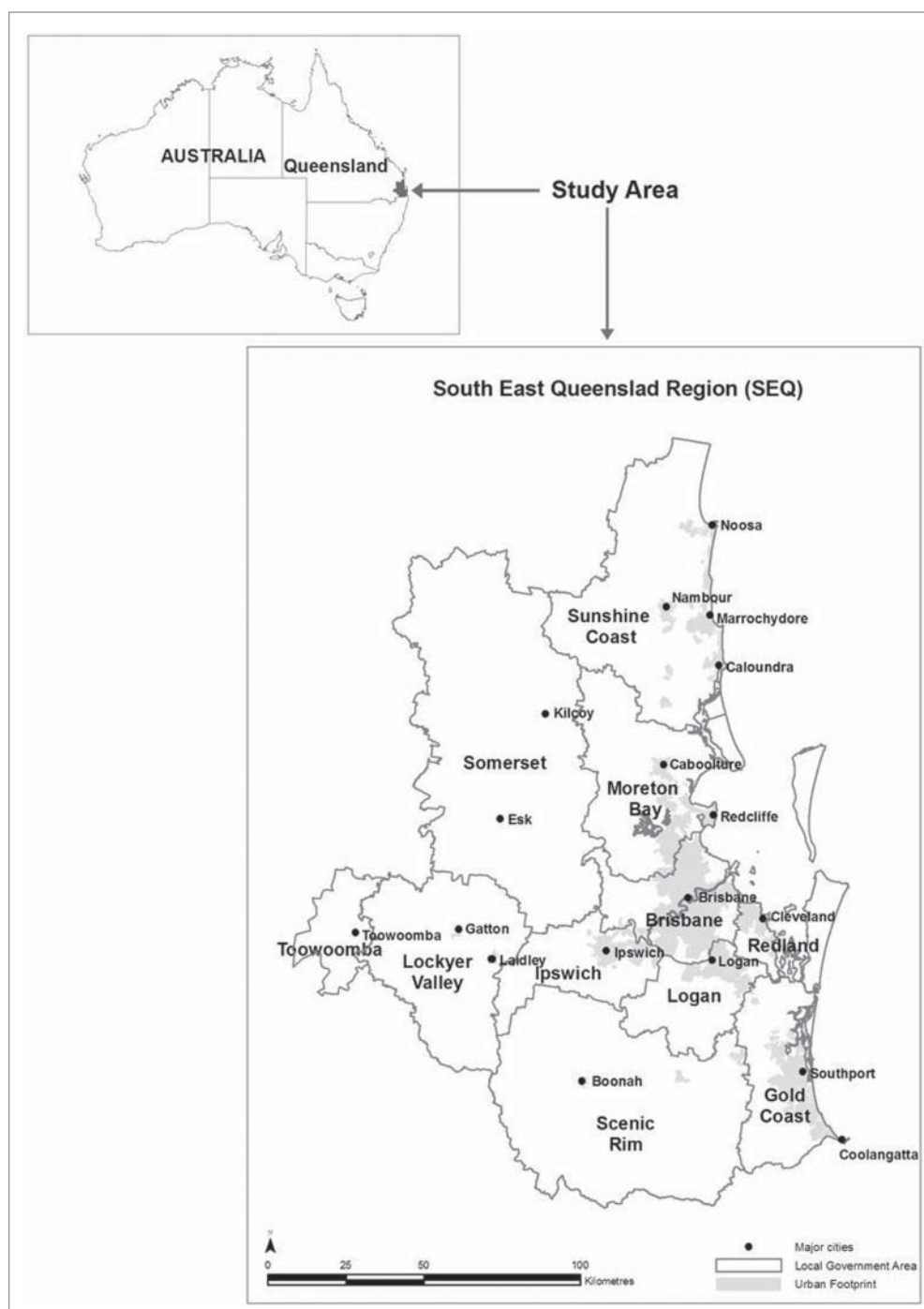
**Table 1.** Attributes of Stakeholder Interviews

Stakeholder group	Number of Interviews	Predominant field of work
Local Government	15	Planning, engineering, human health, emergency management
State Government	7	Planning, engineering, human health, emergency management
Peak Bodies	3	Planning, policy, capacity building
Non-Government Organization	3	Planning, environment, capacity building
Private Sector	2	Engineers, capacity building, human health

**Table 2.** Merits and challenges related to heatwave management plans

Desired Features of Heatwave Management Plans*	Merits	Challenges
Setting strategies to deal with health risks from heatwaves and UHIE <sup>2</sup>	<p>Prioritisation of support to vulnerable groups.<sup>55</sup></p> <p>Planned contingencies for collapse in services (e.g. electricity).<sup>55</sup></p> <p>Identification of cross-sectoral co-beneficial strategies.<sup>22</sup></p> <p>Establishment of working parties.<sup>43</sup></p>	<p>Limitation in defining and understanding spatial distribution of vulnerable groups (e.g. neighbourhood characteristics).<sup>12,15</sup></p> <p>Great variability across groups at risk (e.g. disabilities, workplaces, access to public services).<sup>18,46</sup></p> <p>Poor understanding of community-related factors (e.g. social isolation, socio-economic status).<sup>15,24</sup></p> <p>Lack of services and institutional capacities (e.g. collapse of public transport systems).<sup>27</sup></p>
Links to other sectors (e.g. urban planning and management), professionals (e.g. scientists, health and emergency managers), place-based community resources, and community-based agencies (e.g. Meals on Wheels, Red Cross) <sup>46,27</sup>	<p>Co-beneficial strategies can minimise impacts from heatwaves and UHIE.<sup>26,48,53,61</sup></p> <p>Potential collaboration to improve public and health services awareness and preparedness.<sup>26</sup></p> <p>Delegated responsibility and increased support to community-based organizations.<sup>45,46</sup></p> <p>Better tailored response actions to vulnerable groups.<sup>15, 22</sup></p>	<p>Competing issues and ambivalence from public and urban agencies in defining their own roles and responsibilities.<sup>19,29,62</sup></p> <p>Lack of public services to disadvantaged areas (e.g. public transport; cool places).<sup>63,64</sup></p> <p>Community based organizations require more resources.<sup>15,25,55</sup></p>
Understanding multiple factors influencing vulnerability <sup>20</sup>	<p>Locally-based actions can contribute to the effectiveness of heatwave management measures through allowing better understanding of local factors of vulnerability.<sup>15,26</sup></p>	<p>Limitation in defining and understanding spatial distribution of vulnerable groups with quantitative data alone.<sup>12,44</sup></p> <p>Great variability across factors leading to vulnerability and groups at risk (e.g. people with disabilities, workplaces, elderly, ethnicity and language, social isolation and homelessness, access to public services, socio-economic status, pre-existing medical conditions).<sup>18</sup></p> <p>Poor understanding of community-related factors (e.g. social isolation, socio-economic status).<sup>15</sup></p>
Public engagement in plan making and plan implementation <sup>22,46</sup>	<p>Better understanding of perceptions of risk, enabling tailored health protection measures.<sup>22,24</sup></p> <p>More thorough assessment of hazards and capacities.<sup>46</sup></p> <p>Improved relevance of proposed actions/ targeted interventions.<sup>15</sup></p> <p>Identification of barriers and opportunities to heatwave management initiatives.<sup>31</sup></p>	<p>Perceptions of risk can differ across policy makers, cultural and demographic groups.<sup>22,24,25</sup></p>
Effectiveness of plans (measurement parameters: morbidity and mortality rates; reaching out vulnerable groups)	<p>Locally-based actions can contribute to plans effectiveness.<sup>15,26</sup></p>	<p>Difficulty in attributing morbidity and mortality rates to heatwave management measures.<sup>28</sup></p> <p>Paucity of data regarding effectiveness of plans.<sup>24</sup></p> <p>Community-related factors of heat risks are often poorly understood.<sup>15</sup></p>
Public health response and preparedness (guides for roles and responsibilities of agencies and stakeholders) <sup>35, 61</sup>	<p>Improve both public and health service awareness and preparedness.<sup>26,27</sup></p> <p>A range of strategies to support vulnerable groups can be included in health response guidelines.<sup>24</sup></p>	<p>Competing issues and ambivalence from public, workplaces and urban agencies in defining their own roles and responsibilities.<sup>19,29</sup></p> <p>Reliance on volunteers and social networks with limited resources.<sup>55</sup></p> <p>The effectiveness of initiatives to reduce risks is constrained when the underlying social and economic factors leading to vulnerability are not addressed.<sup>65,66</sup></p>
Communication and public awareness strategies (written guidelines, media, info hot line) <sup>22,35</sup>	<p>Greater dissemination of alerts.<sup>35, 67</sup></p> <p>Risk communication targeting vulnerable groups provide information on ways to reduce heat risks.<sup>22,25,55</sup></p>	<p>Limited information regarding vulnerable groups.<sup>20,25</sup></p> <p>Individuals in vulnerable groups might not perceive themselves as being at risk.<sup>31</sup></p> <p>Need for testing of awareness measures (such as early warning systems and communication strategies) with vulnerable groups.<sup>25,57, 68</sup></p> <p>Often tailored to broader audience without considering needs of vulnerable groups.<sup>69</sup></p> <p>Awareness initiatives need to consider the needs and perceptions of different groups.<sup>28</sup></p> <p>Risk awareness does not necessarily result in behavioural changes.<sup>24,28,70</sup></p>

\*Features extracted from literature, sources indicated after each feature.



**Figure 1.** The SEQ region and local authorities.

the last 100 years, human settlement in SEQ has occurred in the least constrained and easily developed topographical settings, namely the narrow coastal zone and the lower reaches and estuary of the Brisbane River. Hence the majority of the population in SEQ inhabits urban areas with a significant proportion along the urbanized coastal areas extending from the Gold Coast in the south to the Sunshine Coast in the north. The Intergovernmental Panel on Climate Change (IPCC) identifies SEQ as one of the

‘hot spots’ in Australia to be affected by climate change.<sup>34</sup> Despite the uncertainty surrounding current climate science, models have shown that the region will be affected by changes in average rainfall, increased temperatures, sea-level rise and an increase in extreme weather events.<sup>6</sup>

Specifically, annual average temperature is projected to increase between 0.5 and 1.5°C by 2030.<sup>34</sup> In SEQ, a heatwave is defined as 2 or more days of apparent temperature exceeding 36°C.<sup>11</sup> The increase in mean temperatures will also increase the number of days over 35°C in the region, therefore leading to heatwave events. In particular, the current average of 3 days exceeding 35°C is expected to change to 3–6°C by 2030 and 4–35°C by 2070.<sup>7</sup>

There is little reliable information regarding vulnerable groups’ specific behavioral responses to heat in SEQ. In comparison, Australians may exhibit a number of adaptive behaviors during a heatwave such as drinking plenty of water, listening to daily weather forecasts, wearing a hat when going outside, seeking protection of shady areas when outdoors, and/or going for a swim or to an air-conditioned places to cool down.<sup>30</sup>

Although SEQ residents are accustomed to its subtropical climate and warm temperatures, there remains significant health risks associated with heat, particularly for vulnerable groups.<sup>21,36–38</sup> For example, heatwaves and increased ambient heat in Brisbane, the largest

city in SEQ, have been found to have acute effects on morbidity, mortality, emergency hospital admissions and emergency ambulance calls, particularly for elderly people.<sup>16,26,36,39</sup> In the absence of adaptation measures, predicted population growth, temperature increases and an aging population could increase heat-related deaths in Brisbane from the current estimated 134 per year to over 1,000 deaths per year by 2050.<sup>26,40</sup>

Data relating to relationships between ambient high temperatures, mortality and socio-demographic factors is relatively scarce for subtropical regions such as SEQ, and scholars have called for better identification of the region's most vulnerable groups during heatwave events.<sup>17</sup> Anecdotal evidence of previous heatwaves in SEQ indicates that many elderly people as well as other vulnerable groups were largely ignorant of the risks posed by heatwaves or of measures they could take to reduce risks, and that social isolation exacerbated vulnerabilities of many individuals.<sup>41</sup> A study by Loughnan et al. found a significant correlation between adverse health impacts of heat in SEQ and the following: age (particularly for people aged over 65 years), need for assistance, accessibility to emergency services, urban design, aged care facilities, single-person households, population density, UHIE during night-time, and land cover.<sup>18</sup>

Expanded impervious surfaces appear to have led to increased temperatures in SEQ's urban footprint (including coastal urban areas) due to an increased UHIE.<sup>42</sup> Built-up areas in SEQ's major urban center, Brisbane, are generally 2°C warmer than the average temperature, while vegetated areas are up to 3°C cooler.<sup>43</sup> In some neighborhoods relatively high heat exposure is compounded with lower socioeconomic status, making them particularly vulnerable to heat impacts as they are more likely to have reduced mobility options and restricted access to air-conditioned environments (such as private air-conditioned transport, shopping centers and libraries).<sup>31,42</sup> This context calls for additional measures to be put in place as recommended by heatwave management plans, including checking in on vulnerable individuals (through visiting residences or making phone calls), and developing registers of vulnerable people for this purpose; providing accessible cool public spaces and transport to them if necessary; and providing outreach to homeless people.<sup>2,20-24</sup>

## Results

In SEQ, existing research shows that health impacts of heat in the region are significant.<sup>16,17,21,26,35,38-40</sup> Additionally, climate change is likely to exacerbate the risk of heatwaves given the predicted increase in average temperatures in SEQ.<sup>7,11,35</sup> Hence, heatwave management certainly comprises an important task for stakeholders in SEQ to minimize potential heatwave impacts upon its population. Specifically, 7 key themes related to heatwaves emerged from the analysis of the interviews. These included: consideration of heatwaves in disaster management plans, multi-agency approach to managing heatwaves, urban planning measures, improved community engagement and communication, perception of the heatwave problem, role of local government, and community capacity building and resilience. **Table 3** shows illustrative quotes for each theme per sector and type of organization.

For example, some local governments in the region have included considerations of heatwaves as natural hazards in their local disaster management plans in addition to a state-level heatwave response plan.<sup>45,35</sup> For example, a local government interviewee stated that:

"A heatwave would be, or could be, categorized as a natural disaster under our definition of disasters. So our local disaster management group . . . would be responsible for acting in those situations. So the members of that committee made up of all the different areas of responsible people, . . . all the relevant players are in that particular group and basically collectively are making decisions on which messages are put out to the public".

Additionally, a multi-agency approach to respond and manage heatwaves was also highlighted by interviewees. In particular, it was identified that local governments are often in contact with organizations that work closely with many vulnerable groups as a part of the implementation of their disaster management plans. Some interviewees exhibited an appreciation of local government efforts to collaborate with local groups and NGOs to prepare for hot weather, contact vulnerable individuals (such as socially isolated individuals) and send health messages during hot weather. One state government interviewee stressed the importance of locally-based actions that utilize existing networks such as local government personnel, NGOs and community groups servicing people that may be vulnerable to heat:

"Well, I actually like - as I mentioned, the local government work, local conversations about what is a risk for my community in an integrated way rather than say just from a health point of view, so that's helpful."

Such engagement is important and advantageous for the development of heatwave measures as it facilitates the identification of appropriate and relevant measures for vulnerable groups, including, for example, assisting people to access cool places and providing culturally appropriate information to people of diverse backgrounds to manage health risks.<sup>15,22,31,45,46</sup>

The impact of UHIE can be managed through a number of planning measures such as building design and performance standards, tree planting programs and improving urban parklands and design guidelines.<sup>47-50</sup> Our study indicates that there is popularity among SEQ agencies to adopt urban planning measures as an ally to manage heatwave events. Additionally, the use of planning measures to reduce UHIE and improve thermal stress in the built environment was well received among a wide range of stakeholders involved in workshops. In particular, local government personnel highlighted that many local governments in SEQ have also undertaken urban planning measures that reduce the UHIE and encouraged improvements in thermal comfort in the built environment.<sup>51</sup> These include building codes to increase energy efficiency and thermal comfort of the built environment,<sup>52</sup> tree protection bylaws and urban forestry plans.<sup>52</sup> Additionally, thermal imaging and surface temperature mapping with high satellite imagery analysis is used by some local governments in SEQ to identify hot spots in urban areas, however the cost incurred can be prohibitive for some local governments.<sup>52</sup>

Cross-sectoral co-benefits associated with those planning measures are also often acknowledged by stakeholders. For example, there is recognition of the potential for initiatives that combat urban heat to co-benefit other urban management and human health policy goals such as climate change mitigation, health promotion through environments fostering active

**Table 3.** Illustrative examples of quotes for each theme

Theme	Quote	Interview Source
Consideration of heatwaves in disaster management plans	So our local disaster management group . . . would be responsible for acting in those situations	LG, EM
Multi-agency approach to managing heatwaves	if you wanted to say like for example, the vulnerability of the aged, then the community sector and the aged care sector together could take that on board and work with it, with local governments and health as a support working with agencies whether it's Queensland Health or all of those agencies that have vulnerable clients out there	SG, HH NGO, EM
Urban planning measures	You know, there might be other communities things about how you keep cool, plant more trees, whatever, you know, that's all not technically complex because it's pretty straight forward A climate proofed region is one that has really considered its spatial planning well	SG, HH NGO, UPM
Improved community engagement and communication	And there was excess death there but it was mainly in the elderly. So it's a challenge for aged care institutions, isolated elderly. . . People had forgotten their basic messages about how to manage in the heat And I guess elderly people are big thing there and a lot of people say, "Well, you need to use elderly people as a resource and you need to actually be talking with them and seeing whether the heat wave management measures are appropriate to that particular social group."	SG, HH NGO, EM
Perception of the heatwave problem	heat is one of the areas that we'd like to see an investment in and the challenges, we haven't focused on that. We're torn between the heatwaves, doing heatwave work and flood work this summer Community has a level of resilience to heat. . .not unusual for us to get 35+ days for 5-10 days/year	SG, HH LG, EM
Role of local government	local government should be especially identifying areas of vulnerability for different kind of health outcomes associated with climate and identifying hot spots, and maybe that could also be done for strengths as well, like in terms of areas where things are going well.	SG, HH
Community capacity building and resilience	It's all - if we could have an integrated mechanism and sincerely invest in building community resilience that would be ideal. But obviously we do need education, we need people to know to respond and we need local things in place in the event.	SG, HH

SG state government; LG local government; NGO non-government organization, UPM urban planning and management, EM emergency management, HH human health

transport and physical recreation and water sensitive urban design.<sup>53</sup> These are exemplified by the statements below:

"Designing sympathetic urban environments that don't aggravate heat would be interesting and allow for physical activity and things." (State government interviewee)

"Some of the measures of values that we've placed, and when I say values I mean in terms of carbon storage and sequestration estimates, the cooling effects, those kinds of things. . . that's a very important part of our strategy for urban greening." (Local government interviewee)

However, while some workshop participants largely expressed support for improvements to building codes for better thermal comfort in the built environment, and to reduce the UHIE in conjunction with consolidated urban development, others also recommended listening to community responses when planning measures to adapt to increased heat. In particular, some workshop participants called for additional public education and efforts to empower community resilience (although it was not clearly identified how participants agreed this should be done):

"There is a huge return on investment from including the community" "For heat stress – educate and empower community resilience"

The perceptions of the significance of heatwaves as a health issue varied among stakeholders. One stakeholder from a locally based NGO considered heat events to be a significant climate change impact to plan for, while other interviewees saw that heatwaves were not a risk as SEQ residents are accustomed to hot weather and therefore resilient to heatwaves. Some interviewees working with human health and emergency management issues admitted not engaging with heat as a health issue or having given it consideration:

"And you talk about heat. We know that that's going to be one of the huge things . . . it's a natural disaster but they don't call it a natural disaster." (NGO interviewee)

"I'm probably terribly ill-informed but that would be my reading of it. The community is pretty resilient to it. Whether it's 5 or 15 [above 35°C] it's not going to make a massive difference." (Local government interviewee)

"I would suggest if we had that sort of circumstance, the 35–40°C for 15–20°C or whatever it did, I'm not sure how the community would deal with that. But it's a reasonable question to ask as it's probably not something we've given much thought to." (Local government interviewee)

Our study also indicates that there is general appreciation of the role of local governments in addressing heatwave health risks. As outlined by a state government interviewee:

“It needs to be done locally because it’s about personal contact. . . We know what happens when it gets hot but it is very hard locally to actually get the change in place. . . It’s much more ‘roll your sleeves up’ engagement from a departmental point of view.”

Community capacity building approaches were recommended by some interviewees, and considered to be an important part of any resilience-building model:

“If a community is resilient, they’re resilient to war, heat events, a meteor, whatever, so I’d like to see us taking an authentic community building approach.” (State government interviewee)

However, vulnerable groups within the community appear to be not often engaged in heatwave management planning. For example, the development of the state based Heatwave Response Plan did not involve engagement tailored to specific vulnerable groups, despite public engagement being a core aspect of the response plan, nor did it explore ways to target and tailor information to specific identified vulnerable groups (NGO interviewee). Awareness materials and engagement activities for heatwave response in SEQ do not appear to be targeted to vulnerable groups. However, at least one local government in SEQ is embarking on research for a greater understanding of perceptions of risk for different social groups. This is viewed as a long-term learning process for better public awareness relating to environmental health (Local government interviewee).

## Discussion

Heatwave management plans often address preparation and response capabilities of urban institutions.<sup>22,35,54</sup> These plans may include a range of measures such as early warning systems, improved public health response and preparedness, increased public awareness, and guidelines for response roles and responsibilities of agencies and stakeholders (see Table 2). Heatwave management plans can greatly improve both public and health service awareness and preparedness as well as provide a range of strategies to help ensure support for vulnerable groups is prioritized.<sup>55</sup> Awareness strategies may include hotlines providing heat-related health information, providing culturally appropriate information to people of diverse backgrounds to manage health risks and coordinating mass media announcements encouraging people to take measures to reduce heat-related health risks.<sup>2,22-24</sup> Complementary, preparedness strategies could include developing registers of vulnerable people for this purpose and ensuring organizations working with vulnerable groups have protocols and plans in place to manage risks during a heatwave.<sup>2,22-24</sup>

Specifically, heatwave measures are often needed for disadvantaged groups who cannot access air-conditioned houses and cars

during heatwaves, as well as systems for when power fails or is restricted during extreme heat.<sup>29,55</sup> It has been argued that social and community-related factors of heat risks are often poorly understood, with social isolation, socio-economic status and neighborhood characteristics often absent from heatwave management planning.<sup>15,24</sup> The inclusion of various stakeholder groups provides knowledge about local and/or community-specific conditions as well as potential response actions and their effectiveness.<sup>22,24</sup> Such stakeholder groups might include organizations representing and working closely with vulnerable groups, including families and carers of vulnerable individuals as well as well as community and neighborhood level groups.<sup>26,56</sup> Additionally, engaging vulnerable groups in the development and review of heatwave management plans and communication systems helps to ensure that they are effective and appropriate for those groups.<sup>15,22,45</sup>

Nevertheless, risk awareness measures in SEQ are greatly tailored to broader audiences.<sup>57</sup> This is despite the recognition by stakeholders which is also supported by scholars such as Ebi and Semenza of the importance of developing and testing awareness measures tailored specifically for vulnerable groups such as elderly populations.<sup>57</sup> In particular, older Australians and people with disabilities often have limited access to information, resources and/or community participation, making them potentially more difficult to reach.<sup>55</sup> Similarly, people of culturally and linguistically diverse backgrounds may have limited access to health warnings due to linguistic and social isolation, language barriers and low literacy rates. This vulnerability is exacerbated by higher levels of socioeconomic disadvantage, cultural factors, health issues, poor housing conditions and limited access to air-conditioning for many culturally and linguistically diverse communities in Australia.<sup>25</sup>

The development of heatwave management plans in SEQ has involved collaboration of a range of stakeholders, including organizations that work closely with vulnerable groups (such as elderly and homeless people, and lower socioeconomic communities) to address risks. Disaster plans such as these can enable support for vulnerable groups to be prioritized as well as planned contingencies for potential collapse in services during a heatwave.<sup>55</sup> Collaborative disaster management arrangements that allow active involvement of organizations representing the interests of vulnerable groups (such as found in SEQ) enable the auto-assessment of hazards and capacities.<sup>46,57</sup> These arrangements can also assist in identifying cross-sectoral co-beneficial strategies, barriers and opportunities for heatwave management initiatives<sup>31,46</sup> as well as in developing actions that are tailored to vulnerable groups.<sup>15,22,57</sup> Additionally, Hansen et al.’s study suggests that strong partnerships at a local level, particularly between government and community organizations facilitate effective heatwave management for vulnerable groups.<sup>25</sup>

However, our study indicates that although SEQ agencies have concentrated efforts to develop and implement heatwave management plans across the region, there remains a critical gap in those efforts which is related to the poor engagement and focus on vulnerable groups. For example, despite the acknowledgment by stakeholders of the importance and advantages of engaging with vulnerable groups, it is not clear that these advantages have

translated into formal locally-based heatwave plans for most local governments in SEQ. Literature reveals that there is great variability across groups at risk, that poor understandings of community-related factors can constrain the effectiveness of heatwave management plans, and that better understanding of perceptions of risk and barriers to behavioral change enables tailored health protection measures.<sup>15,18,22,24,30,31,46</sup> Following this evidence from the literature, heatwave management in SEQ could benefit from greater engagement with vulnerable groups to increase understanding of perceptions of risk and barriers to behavioral change, and tailor heatwave management accordingly.

Community capacity building approaches that view vulnerable groups as resources and as people that can play a key role in reducing risks are sought after by many stakeholders.<sup>45,46</sup> Indeed, expectations that information alone will result in reduced ambivalence to heat risks and changes in behavioral responses to risk may be unrealistic.<sup>24,28,30,58</sup> Community-specific health protection measures that use existing social networks and local community-based organizations can be useful to synthesize a higher level of collective knowledge, and generate a greater understanding of why vulnerable groups may fail to change behaviors to reduce heat-related health risks and/or become ill during heatwaves despite being exposed to public health messages.<sup>15,21,26,31,59</sup> For example, a post-heatwave focus group of community organizations undertaken in Melbourne, Australia indicated that these measures also may include improvements in funding and communication arrangements between government agencies and community organizations during heatwave response.<sup>27</sup> Additionally, Yardley et al. proposed the development of community-specific action plans and the preparation of needs assessments by people living in vulnerable neighborhoods themselves.<sup>15</sup> These measures could increase the understanding of heatwave risks among vulnerable groups thereby facilitating and encouraging behaviour change during heatwave events such as seeking shelter in cooler places and drinking plenty of water.

However, Wolf cautions that strong social networks should not be assumed to translate into greater adaptive capacity to address extreme heat, and that any dangerously low perceptions of risk held in social networks need to be understood and addressed.<sup>60</sup> Comments suggesting ambivalence toward issues of health risks from heatwaves support research findings asserting the presence of ambivalence toward heat in Australia, and assertions of differing perceptions of risk among policy makers.<sup>22,29</sup> Several studies suggest that such ambivalence may be a problem where it leads to a failure to make serious efforts to minimize adverse health impacts of heatwaves, or to even consider health impacts of heat as an important topic of research.<sup>19,29,30</sup>

Although many stakeholders said they wanted to see the community empowered to reduce risks associated with heat, could this also be constrained by ambivalence and limited community interest? Additionally, reliance on volunteers and social networks can be problematic where they are not adequately resourced.<sup>55</sup> Consequently, more information is needed on vulnerable subgroups to better understand their perceptions of risk, and potential for risk reduction initiatives that involve active involvement and direction from community groups.

## Conclusion

This paper aimed to broaden the understanding of how heatwave management measures could be improved as part of climate change adaptation responses by focusing on the example provided by the SEQ region in Australia. Heatwaves in SEQ have a significant impact on morbidity, mortality and hospital admissions. In the absence of adaptation measures, health risks associated with heatwaves and extreme heat events will increase due to climate change, an aging population and urban growth. Urban planning measures to reduce the UHIE and improve thermal comfort of the built environment are very popular among human health, urban planners and emergency management professionals across the region. As well as reducing urban heat, these measures also often benefit a range of other urban policy goals.

Perceptions of risk of heatwaves differ among stakeholders in SEQ. In particular, more information is needed on vulnerable groups and their perceptions of heat risk. However, to be effective this type of information needs to be constantly updated therefore demanding the allocation of appropriate resources in financial and human terms.<sup>71</sup> More heat-specific engagement may be needed to better understand likely effectiveness of different measures for vulnerable groups and allow community ownership of heat responses where community interest exists. Innovative information dissemination methods are also needed and should be targeted and tailored specifically to vulnerable groups.<sup>71</sup>

In the specific case of SEQ, more research is needed to generate a better understanding of vulnerable groups and the potential for demographic and socioeconomic characteristics to influence and shape behavioral responses to hot weather. This includes information on the efficiency of health messages encouraging individual and institutional workers to promote adaptive behaviors that can minimize the health impact of heatwave events including appropriate individual hydration and cooling strategies.<sup>30</sup> Research is also needed to generate an understanding of different social groups in the region and how they may interpret and engage with risk communication and heatwave management measures as well as their own perception as to whether they comprise a risk group. This would help inform health organizations of the current behavioral responses to heat of vulnerable groups, as well as the most achievable and suitable behavioral responses to hot weather and associated communication strategies to manage health risks that correspond with local geographical and social contexts.

## Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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The authors of this paper complied with all the legal requirements pertaining to the location in which the work was done.

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## Note

<sup>a</sup>Managing health impacts of heat in South East Queensland, Australia.

## References

- Turner LR, Connell D, Tong S. The effect of heat waves on ambulance attendances in Brisbane, Australia. *Prehosp Disaster Med* 2013; 28:482-7; PMID:23981779; <http://dx.doi.org/10.1017/S1049023X13008789>
- Koppe C, Kovats S, Jendritzky G, Menne B. Heatwaves: risks and responses. *Health Global Environ Change Series*, No.2 2004.
- Kovats RS, Hajat S. Heat stress and public health: a critical review. *Annu Rev Public Health* 2008; 29:41-55; PMID:18031221; <http://dx.doi.org/10.1146/annurev.publhealth.29.020907.090843>
- Reid CE, O'Neill MS, Gronlund CJ, Brines SJ, Brown DG, Diez-Roux AV, Schwartz J. Mapping community determinants of heat vulnerability. *Environ Health Persp* 2009; 117:1730; PMID:20049125
- Tong S, Wang XY, Barnett AG. Assessment of heat-related health impacts in brisbane, Australia: comparison of different heatwave definitions. *PLoS ONE* 2010; 5:e12155; PMID:20730050; <http://dx.doi.org/10.1371/journal.pone.0012155>
- CSIRO. Climate change in Australia. Technical Report 2007 (online), Available: [http://www.climatechangeinaustralia.gov.au/technical\\_report.php](http://www.climatechangeinaustralia.gov.au/technical_report.php) (20 May 2010), 2007.
- Walsh K, Cai W, Hennessy K, Jones R, McInnes K, Nguyen K, Page C, Whetton P. Climate Change in Queensland under Enhanced Greenhouse Conditions, Final Report, Report on research undertaken for Queensland Departments of State Development, Main Roads, Health, Transport, Mines and Energy, Treasury, Public Works, Primary Industries, and Natural Resources, CSIRO. 2002.
- Coutts A, Beringer J, Tapper N. Changing urban climate and CO<sub>2</sub> emissions: implications for the development of policies for sustainable cities. *Urban Policy Res* 2010; 28:27-47; <http://dx.doi.org/10.1080/08111140903437716>
- Stone B, Norman JM. Land use planning and surface heat island formation: A parcel-based radiation flux approach. *Atmos Environ* 2006; 40:3561-73; <http://dx.doi.org/10.1016/j.atmosenv.2006.01.015>
- Flyvberg B. Five misunderstandings about case-study research. *Qual Inq* 2006 12:219-45; <http://dx.doi.org/10.1177/1077800405284363>
- Suppiah R, Hennessy K, Whetton P, McInnes K, Macadam I, Bathols J, Ricketts J, Page C. Australian climate change projections derived from simulations performed for the IPCC 4th Assessment Report. *Aust Meteorol Mag* 2007; 56:131-52.
- Mersereau V, Penney J. Developing a geospatial decision support system to address extreme heat and the urban heat island effect in the Greater Toronto Area: A user needs assessment, prepared for GeoConnections March 2008, Toronto: Clean Air Partnership 2008.
- Rosenthal JK, Crauderueff R, Carter M. Urban heat island mitigation can improve New York City's environment: research on the impacts of mitigation strategies on the urban environment, a Sustainable South Bronx Working Paper October 2008. Sustainable South Bronx, 2008.
- Ambrose M, Miller A, O'Hare D. Subtropical subdivisions: toward a lot-rating methodology for subtropical climates Subtropical Cities 2006 conference proceedings: achieving ecologically sustainable urbanism in a subtropical built environment, 27-29 September 2006, Brisbane, Australia, 2006.
- Yardley J, Sigal RJ, Kenny GP. Heat health planning: The importance of social and community factors. *Global Environ Change* 2011; 21:670-9; <http://dx.doi.org/10.1016/j.gloenvcha.2010.11.010>
- Wang XY, Barnett AG, Yu W, FitzGerald G, Tippet V, Aitken P, Neville G, McRae D, Verrall K, Tong S. The impact of heatwaves on mortality and emergency hospital admissions from non-external causes in Brisbane, Australia. *Occup Environ Med* 2012; 69:163-9; PMID:21719563; <http://dx.doi.org/10.1136/oem.2010.062141>
- Yu W, Vaneckova P, Mengersen K, Pan X, Tong S. Is the association between temperature and mortality modified by age, gender and socio-economic status? *Sci Total Environ* 2010; 408:3513-8; PMID:20569969; <http://dx.doi.org/10.1016/j.scitotenv.2010.04.058>
- Loughnan M, Tapper NJ, Phan T, Lynch K, McInnes JA. A spatial vulnerability analysis of urban populations during extreme heat events in Australian capital cities. Monash University, 2013.
- Singh S, Hanna EG, Kjellstrom T. Working in Australia's heat: Health promotion concerns for health and productivity. *Health Promot Int* May 2013; PMID:23690144
- Uejio CK, Wilhelm OV, Golden JS, Mills DM, Gulino SP, Samenow JP. Intra-urban societal vulnerability to extreme heat: The role of heat exposure and the built environment, socioeconomics, and neighborhood stability. *Health Place* 2011; 17:498-507; PMID:21216652; <http://dx.doi.org/10.1016/j.healthplace.2010.12.005>
- Bi P, Williams S, Loughnan M, Lloyd G, Hansen A, Kjellstrom T, Dear K, Saniotis A. The effects of extreme heat on human mortality and morbidity in Australia: implications for public health. *Asia-Pacific J Pub Health* 2011; 23:27S-36S; PMID:21247972; <http://dx.doi.org/10.1177/1010539510391644>
- van Iersel R, Bi P. The impact of heat waves on the elderly living in Australia: How should a heat health warning system be developed to protect them? *Range-land J* 2009; 31:277-81; <http://dx.doi.org/10.1071/RJ08036>
- England PH. Heatwave Plan for England 2013, Looking after yourself and others during hot weather - the latest advice. In: England PH, ed.: NHS England, 2013.
- Bassil KL, Cole DC. Effectiveness of public health interventions in reducing morbidity and mortality during heat episodes: a structured review. *Int J Environ Res Pub Health* 2010; 7:991-1001; PMID:20617014; <http://dx.doi.org/10.3390/ijerph7030991>
- Hansen A, Bi P, Saniotis A, Nitschke M, Benson J, Tan Y, Smyth V, Wilson L, Han G. Extreme heat and climate change: adaptation in culturally and linguistically diverse (CALD) communities. Gold Coast: Nat Clim Change Adaptation Res Facility 2013; pp101.
- PricewaterhouseCoopers Australia. Protecting human health and safety during severe and extreme heat events: a national framework. 2011.
- Queensland University of Technology. Impacts and adaptation response of infrastructure and communities to heatwaves: the southern Australian experience of 2009. Gold Coast, Australia, 2010.
- Toloo G, FitzGerald G, Aitken P, Verrall K, Tong S. Evaluating the effectiveness of heat warning systems: systematic review of epidemiological evidence. *Int J Pub Health* 2013; 58(5):667-81; PMID:23207603
- Banwell C, Dixon J, Bambrick H, Edwards F, Kjellström T. Socio-cultural reflections on heat in Australia with implications for health and climate change adaptation. *Glob Health Action, CoAction Publishing* 2012; 5:19277; PMID:23078748
- Akompab DA, Bi P, Williams S, Grant J, Walker IA, Augoustinos M. Heat waves and climate change: Applying the health belief model to identify predictors of risk perception and adaptive behaviours in adelaide, Australia. *Int J Environ Res Pub Health* 2013; 10:2164-84; PMID:23759952; <http://dx.doi.org/10.3390/ijerph10062164>
- Abrahamson V, Wolf J, Lorenzoni I, Fenn B, Kovats S, Wilkinson P, Adger WN, Raine R. Perceptions of heat-wave risks to health: interview-based study of older people in London and Norwich, UK. *J Pub Health* 2009; 31:119-26; PMID:19052099; <http://dx.doi.org/10.1093/pubmed/fdn102>
- Newell CJ, South J. Participating in community research: exploring the experiences of lay researchers in Bradford. *Commun, Work Family* 2009; 12:75-89; <http://dx.doi.org/10.1080/13668800802627934>
- Van Aalst MK, Cannon T, Burton I. Community level adaptation to climate change: the potential role of participatory community risk assessment. *Glob Environ Change* 2008; 18:165-79; <http://dx.doi.org/10.1016/j.gloenvcha.2007.06.002>
- Hennessy K, Fitzharris B, Bates BC, Harvey N, Howden M, Hughes L, Salinger J, Warrick R. Australia and New Zealand. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE, eds. *Climate Change 2007: Impacts, Adaptation and Vulnerability Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press, 2007:507-40.
- Queensland Health. Queensland Heatwave Response Plan. Queensland Health, 2004:25.
- Yu W, Mengersen K, Wang X, Ye X, Guo Y, Pan X, Tong S. Daily average temperature and mortality among the elderly: a meta-analysis and systematic review of epidemiological evidence. *Int J Biometeorol* 2012; 56:569-81; PMID:21975970; <http://dx.doi.org/10.1007/s00484-011-0497-3>
- Yu W, Hu W, Mengersen K, Guo Y, Pan X, Connell D, Tong S. Time course of temperature effects on cardiovascular mortality in Brisbane, Australia. *Heart* 2011; 97:1089-93; PMID:21487126; <http://dx.doi.org/10.1136/hrt.2010.217166>
- Auliciems A, Skinner J. Cardiovascular deaths and temperature in subtropical Brisbane. *Int J Biometeorol* 1989; 33:215-21; PMID:2613364; <http://dx.doi.org/10.1007/BF01051080>
- Tong S, Wang XY, Guo Y. Assessing the short-term effects of heatwaves on mortality and morbidity in brisbane, Australia: comparison of case-crossover and time series analyses. *PLoS ONE* 2012; 7:e37500.
- McMichael AJ. Climate change and human health: risks and responses. World Health Organization, 2003.
- Granger K, Brerchree M. Heat wave risks. In: Granger K, Hayne M, eds. *Natural hazards and the risks they pose to South-East Queensland: Australian Geological Survey Organization*, 2000.
- Low Choy D, Baum S, Serrao-Neumann S, Crick FS, M, Harman B. Climate Change Vulnerability in South East Queensland: A Spatial and Sectoral Assessment. A report for the South East Queensland Climate Adaptation Research Initiative, Griffith University, 2010.
- Loh S Stav Y. Green a city grow a wall. Proceedings of the Subtropical Cities 2008 Conference: From Fault-

- lines to Sight-lines: Subtropical Urbanism in 20-20: Centre for Subtropical Design, Queensland University of Technology, 2008:1-9.
44. Moreton Bay Regional Council Local Disaster Management Group. Moreton Bay Regional Council Local Disaster Management Plan. Moreton Bay Regional Council, 2011.
  45. Chatman P. Heatwave warning system is imperative. EMERGENCY: Queensland Government, Department of Emergency Services, 2006:11-3.
  46. Wilhelmi OV, Hayden MH. Connecting people and place: a new framework for reducing urban vulnerability to extreme heat. *Environ Res Lett* 2010; 5:014021; <http://dx.doi.org/10.1088/1748-9326/5/1/014021>
  47. Smoyer-Tomic KE, Rainham D. Beating the heat: development and evaluation of a Canadian hot weather health-response plan. *Environ Health Perspec* 2001; 109:1241; PMID:11748031; <http://dx.doi.org/10.1289/ehp.011091241>
  48. Coutts AM, Beringer J, Tapper NJ. Impact of increasing urban density on local climate: spatial and temporal variations in the surface energy balance in Melbourne, Australia. *J App Meteorol Climatol* 2007; 46:477-93; <http://dx.doi.org/10.1175/JAM2462.1>
  49. Bambrick HJ, Capon AG, Barnett GB, Beaty RM, Burton AJ. Climate change and health in the urban environment: adaptation opportunities in Australian cities. *Asia-Pacific J Pub Health* 2011; 23:67S-79S; PMID:21242151; <http://dx.doi.org/10.1177/1010539510391774>
  50. Forkes J. Mitigating urban heat in Canada: Urban heat island summit 2010. In: Penney J, Dickinson T, Ligeti L, Behan K, Storfer J, Berry P, eds. Toronto: Clean Air Partnership, 2010.
  51. Gold Coast City Council. Sustainable Building & Renovation. Sustainable Living. Gold Coast City, 2013.
  52. Brisbane City Council. Brisbane City Plan 2000. In: Council BC, ed. Brisbane, 2013:73-6.
  53. Coutts AM, Tapper NJ, Beringer J, Loughnan M, Demuzere M. Watering our cities The capacity for Water Sensitive Urban Design to support urban cooling and improve human thermal comfort in the Australian context. *Prog Phys Geog* 2013; 37:2-28; <http://dx.doi.org/10.1177/0309133312461032>
  54. McMichael AJ, Woodruff RE, Hales S. Climate change and human health: present and future risks. *The Lancet* 2006; 367:859-69; [http://dx.doi.org/10.1016/S0140-6736\(06\)68079-3](http://dx.doi.org/10.1016/S0140-6736(06)68079-3)
  55. Disability Disaster Advocacy Group. heatwave planning guide: development of heatwave plans in local councils in Victoria, submission Action for Community Living, Council on the Ageing (Victoria), 2009.
  56. Public Health England. Heatwave Plan for England 2013: supporting vulnerable people before and during a heatwave – advice for health and social care professionals. In: Public Health England, ed.: NHS England, 2013.
  57. Ebi KL, Semenza JC. Community-based adaptation to the health impacts of climate change. *Am J Preventive med* 2008; 35:501-7; PMID:18929976; <http://dx.doi.org/10.1016/j.amepre.2008.08.018>
  58. Oudin Åström D, Bertil F, Joacim R. Heat wave impact on morbidity and mortality in the elderly population: a review of recent studies. *Maturitas* 2011; 69:99-105; <http://dx.doi.org/10.1016/j.maturitas.2011.03.008>
  59. Hansen A, Bi P, Nitschke M, Pisaniello D, Newbury J, Kitson A. Perceptions of heat-susceptibility in older persons: Barriers to adaptation. *Int J Environ Res Pub Health* 2011; 8:4714-28; PMID:22408598; <http://dx.doi.org/10.3390/ijerph8124714>
  60. Wolf J, Adger WN, Lorenzoni I, Abrahamson V, Raine R. Social capital, individual responses to heat waves and climate change adaptation: An empirical study of two UK cities. *Glob Environ Change* 2010; 20:44-52; <http://dx.doi.org/10.1016/j.gloenvcha.2009.09.004>
  61. Harlan SL, Ruddell DM. Climate change and health in cities: impacts of heat and air pollution and potential co-benefits from mitigation and adaptation. *Curr Opin Environ Sustainability* 2011; 3:126-34; <http://dx.doi.org/10.1016/j.cosust.2011.01.001>
  62. Abrahamson V, Raine R. Health and social care responses to the Department of Health Heatwave Plan. *J Pub Health* 2009; 31:478-89; PMID:19542549; <http://dx.doi.org/10.1093/pubmed/fdp059>
  63. Johnson L, Herath S. Big roads, no transport: a report of the Goodna and Gailes community mapping for transport improvements study. Urban Policy Program Research Monograph. Griffith University, Brisbane, Australia; December 2004.
  64. Dodson J, Gleeson B, Sipe NG. Transport Disadvantage and Social Status: A Review of Literature and Methods. Urban Policy Program, Griffith University Brisbane, 2004.
  65. Zaidi RZ, Pelling M. Institutionally configured risk: Assessing urban resilience and disaster risk reduction to heat wave risk in London. *Urban Studies* 2013;0042098013510957.
  66. Maller CJ, Strengers Y. Housing, heat stress and health in a changing climate: Promoting the adaptive capacity of vulnerable households, a suggested way forward. *Health promot Int* 2011; 26:492-8; PMID:21307023; <http://dx.doi.org/10.1093/heapro/dar003>
  67. Kalkstein LS, Sheridan SC, Kalkstein AJ. Heat/health warning systems: development, implementation, and intervention activities. *Biometeorology for adaptation to climate variability and change*: Springer, 2009:33-48; [http://dx.doi.org/10.1007/978-1-4020-8921-3\\_3](http://dx.doi.org/10.1007/978-1-4020-8921-3_3)
  68. Toloo GS, FitzGerald G, Aitken P, Verrall K, Tong S. Are heat warning systems effective? *Environ Health* 2013; 12:27; PMID:23561265; <http://dx.doi.org/10.1186/1476-069X-12-27>
  69. Lowe D, Ebi KL, Forsberg B. Heatwave early warning systems and adaptation advice to reduce human health consequences of heatwaves. *Int J Environ Res Pub Health* 2011; 8:4623-48; PMID:22408593; <http://dx.doi.org/10.3390/ijerph8124623>
  70. Kovats RS, Kristie LE. Heatwaves and public health in Europe. *Eur J Pub Health* 2006; 16:592-9; <http://dx.doi.org/10.1093/eurpub/ckl049>
  71. Abrahamson V, Raine R. Health and social care responses to the Department of Health Heatwave Plan. *J Pub Health* 2009; 31:478-89; PMID:19542549; <http://dx.doi.org/10.1093/pubmed/fdp059>