Health Promotion International, Vol. 26 No. 4
doi:10.1093/heapro/dar003
Advance Access published 8 February, 2011

Housing, heat stress and health in a changing climate: promoting the adaptive capacity of vulnerable households, a suggested way forward

CECILY J. MALLER* **and YOLANDE STRENGERS**
Centre for Design, RMIT University, Melbourne, Australia
**Corresponding author. E-mail: cecily.maller@rmit.edu.au*

SUMMARY

In many places extreme heat causes more deaths than floods, cyclones and bushfires. However, efforts to manage the health implications of heat and increase the adaptive capacity of vulnerable populations are in their infancy, requiring urgent attention from research and policy. This paper presents a case for research exploring the influence of social and contextual factors on vulnerable populations' capacity to adapt to heat in the context of climate change. We argue such research is imperative given current prioritization of short-sighted policy solutions such as installation and use of greenhouse-intensive domestic air-conditioners as moderators of heat stress. Globally, vulnerability to heat stress is most often assessed by epidemiological analysis of past morbidity and mortality data; yet a range of other factors need to be accounted for in interpreting and understanding these patterns of ill-health and loss of life, and further in determining how vulnerability is created, exacerbated and alleviated by broader societal conditions. Such factors include: the cooling technologies and infrastructures available to householders, practical knowledge about how to moderate heat stress, and social and cultural understandings of comfort and vulnerability. To investigate these factors, new methodologies are required. Social practice theory, which conceptualizes the dynamic interactions between individuals and wider systems of power, infrastructure, technologies, society and culture as components of practices such as household cooling, is presented as a way forward. The development of a practice-based methodology and conceptual framework to understand adaptation to heat will provide a multidimensional, systems-oriented understanding of how vulnerability can potentially be reduced.

Key words: capacity building; policy; heat; urban environments

INTRODUCTION

Currently, extreme heat events are responsible for more deaths in some countries than floods, cyclones and bushfires (Klinenberg, 2002; McMichael *et al*., 2008); yet programmes, policies and research to manage extreme heat events and increase adaptation to heat are in their infancy. Due to ageing populations, hotter summers induced by climate change, trends towards increasing urbanization and greenhouse-intensive air-conditioner usage in developed nations, research on adaptation to extreme heat warrants urgent research and policy attention. In particular, research is needed to understand adaptation opportunities that provide alternatives to reactive 'one-size-fits-all solutions' such as distribution of air-conditioning units, a measure that is cautioned against (Brown and Walker, 2008), but nonetheless widely promoted and accepted by key policy-makers and health organizations.

Climate change is the most widely discussed global environmental change. Frumkin *et al.* [(Frumkin *et al*., 2008), p. 403] suggest the question of whether climate change will

impact public health has been settled, with a response in the affirmative: 'Climate change [is] an environmental health hazard of unprecedented scale and complexity'. Although some health benefits from climate change are expected (varying according to locale), including reduced cold-related mortality, overall the balance of impacts will be 'overwhelmingly negative' [(Confalonieri *et al*., 2007), p. 407]. These issues are particularly pertinent for Australia, which has been slower than other countries to respond to this particular impact of climate change and where 'existing research capacity is low' [(McMichael *et al*., 2008), p. 17]. Frumkin *et al.* [(Frumkin *et al*., 2008), p. 403] pose the key question for health professionals is not *whether* or *why*, but *what* and *how*: What needs to be done to prevent injury, illness and suffering related to climate change and how to do it most effectively? We suggest that this question can also be put to planners and policy-makers.

As past research has clearly established the causal link between housing and health [e.g. (Evans *et al*., 2003; Howden-Chapman, 2004; Lawrence, 2004; Chapman *et al*., 2009)], this paper presents the case for research exploring the influence of social and contextual factors, in particular the thermal comfort of housing, on vulnerable populations' capacity to adapt to extreme heat in the context of climate change. Without specifying a detailed project, we propose a broad research agenda grounded in the everyday settings of people's homes that explores the nexus of social and contextual variables in conjunction with the impacts of heat on health and wellbeing, whilst seeking to maximize opportunities for adaptation. Such variables include the thermal performance of housing, the cooling technologies and infrastructures available to householders, practical knowledge about how to moderate heat stress and social and cultural understandings of comfort and vulnerability.

After Kelly and Adger (Kelly and Adger, 2000), we define 'vulnerability' in terms of the capacity of households and communities to cope with, recover from and adapt to external stressors that effect their wellbeing. We choose this definition because it accounts for socio-economic and institutional factors that moderate the ability of households to respond (Kelly and Adger, 2000) to heat events and other impacts of climate change.

DEATHS AND ILLNESS FROM HEAT

The main findings of the IPCC relating to human health predict, among other impacts, there will be an increase in the frequency or intensity of heat waves and heat-related morbidity and mortality (McMichael and Githeko, 2001). In 2007, the IPCC reported with 'medium confidence' that emerging evidence of climate change effects on human health shows that it has increased heat wave-related deaths. Heat-related mortality is due to heat stroke and exacerbation of existing health problems (Smoyer, 1998). Other morbidity effects of temperature extremes include impairment of physiological functioning, mood, behaviour (i.e. accident-proneness) and reduced workplace productivity in outdoor and factory workers (Kjellstrom, 2009 in McMichael, 2009). For example, the 2003 heat wave in Western Europe was responsible for ~40 000–50 000 deaths (Confalonieri *et al*., 2007).

Projections indicate the number of annual deaths due to heat stress in Australia's major cities will rise from 1115 in 2003 to 2300–2500 in 2020 and 4300–6300 by 2050 (McMichael *et al*., 2003 in Hennessy *et al*., 2007). Further, temperate cities in Australia are expected to experience higher heat-related deaths than tropical ones, and the current winter peak in deaths will be overtaken by heat-related mortality in nearly all cities by 2050 (McMichael *et al*., 2003 in Hennessy *et al*., 2007), increasing by up to two to three times (McMichael, 2009). Clearly, there is an urgent imperative for health professionals, planners and policy-makers to develop proactive responses that act to prevent and minimize deaths from heat.

AIR-CONDITIONING: A SHORT-SIGHTED SOLUTION

The reactionary and immediate response to the concerns raised above is to install air-conditioners in vulnerable households—an approach recommended by the Victorian arm of the Australian Medical Association (AMA, 2010). However, air-conditioning is neither a technically feasible option in the short term nor an environmentally (and economically) sustainable option in the longer term. Although air-conditioning clearly has a role to play in

preventing heat stress, we caution against relying on it as the dominant or only solution.

The most compelling reason for shifting emphasis away from this 'technical-fix' solution is not a climate-related one. Rather, Australia's temperate cities are experiencing significant peak demand problems caused primarily by increasing residential air-conditioner use, leading to regular blackouts on hot summer days. Rising peak demand is also responsible for current and predicted residential electricity price rises as more infrastructures are required to meet the demand on a small number of days each year (Strengers, 2008). At present, peak demand requires economically inefficient investment in new electricity infrastructure which is only used for 1–2% of the year (DPI, 2009)—a cost which is currently passed on to all electricity consumers (with or without air-conditioning). These price increases will add to the heat-related vulnerability of low-income households, who may be unable to pay for cooling services. Furthermore, vulnerable households relying on air-conditioning during heat-related events will be left more vulnerable if blackouts occur on the hottest days when peak demand is at its worst.

Cooling (and heating) appliances dominate household energy use (41%) and account for nearly one-fifth (19%) of Australia's residential greenhouse gas emissions (ABS, 2008), thereby potentially exacerbating the very problem they seek to address. National residential air-conditioning penetration has risen to 67% from just over 10% 40 years ago (ABS, 2008). Most of this growth has occurred in the last 10 years where there has been a doubling of penetration (DEWHA, 2008). Cooling energy use in the residential sector is projected to increase by a factor of five from 1990 to 2020 (DEWHA, 2008) and a similar resource-intensive escalation is occurring in other OECD (OECD, 2002) countries.

While a range of social and contextual factors have led to the air-conditioner's increasing uptake, the changing built environment stands out. Air-conditioners, or outlets for them, are being offered as 'standard' by project home builders to gain a marketing edge (Wilkenfeld, 2004). In addition, declining block sizes and increasing floor areas are reducing scope to optimize orientation and retain mature tree cover in new subdivisions. There is also an increasing number of high rise apartments with poor shading and glazing which are less able to rely on natural ventilation (Wilkenfeld, 2004). Revised building shell performance standards only affect 2% of total stock per annum, and have so far only managed to slow (rather than reverse or stabilize) the escalating resource consumption associated with air-conditioned cooling (and heating) practices (Wilkenfeld, 2007; DEWHA, 2008).

As a result of these homogenizing trends, other potential ways to achieve 'coolth' are being obscured. For example, De Dear and Brager (De Dear and Brager, 2002) argue that households living year-round in air-conditioned spaces are likely to develop high expectations for homogeneity and become acclimatized to a narrow range of temperatures. Adaptive comfort and passive cooling studies also show that the ambient temperature of rooms can be significantly reduced with minimal energy input through infrastructure changes and social organization (Nicol and Roaf, 2007; Santamouris, 2007). For example, the City of Philadelphia in the USA, which runs a Cool Homes Programme for elderly low-income residents, found that passive cooling measures, such as fans, interior air sealing and elastometric roof coating, reduced indoor temperatures by 2.5°C (Santamouris, 2007). In another study, Nicol and Roaf (Nicol and Roaf, 2007) discuss the thermal routines of a cultural group in Iran, who have adapted their daily practices around the climate by moving around the house during the seasons to the coolest or warmest parts. Similarly, nearly all Australian householders have lived without air-conditioning at some point in their lives (EES, 2006), and have developed adaptive strategies of coping with and adapting to heat (Williamson *et al.*, 1991; Strengers, 2009). This adaptive capacity is largely ignored in heat stress policy and research, as is the role of the built environment in moderating heat stress, to which changes are considered a long-term goal.

VULNERABILITY AND ADAPTATION TO HEAT: THE IMPORTANCE OF SOCIAL AND CONTEXTUAL FACTORS

Globally, vulnerability to heat stress is currently assessed by epidemiological analysis of past mortality data (Brown and Walker, 2008). Studies conducted in a range of locations and

climates have shown that older people comprise the majority of victims in hot weather events, most likely because they have pre-existing conditions such as cardiovascular disease and type 2 diabetes (Brown and Walker, 2008). However, other groups identified as vulnerable include low-income households (Smoyer, 1998; Borrell *et al*., 2006; Harlan *et al*., 2006; Rey *et al*., 2009), young children, the homeless and those with mental ill-health (Bouchama *et al*., 2007). Vulnerability is also increased for those residing in urban areas due to the urban heat island effect (Harlan *et al*., 2006). In their review of studies on this topic, Brown and Walker (Brown and Walker, 2008) state patterns of mortality and morbidity are not due to physiology alone. A range of social and contextual factors need to be accounted for in interpreting and understanding mortality and morbidity patterns and assessing how vulnerability is created (Brown and Walker, 2008). For example, studies conducted in France and the USA found that a lack of mobility, sleeping on the top floor of a building and building performance variables such as insulation are key risk factors in heat related mortality (Vandentorren *et al*., 2006). A key difference between the studies was isolation: in the USA living alone was associated with a higher risk of heat related death, whereas in France the level of risk remained unchanged (Semenza *et al*., 1996 in Brown and Walker, 2008).

However, much of the work to date on vulnerability assessment has relied on large-scale quantitative data that potentially obscure the subtleties and complexities of vulnerable populations (Brown and Walker, 2008), such as those observed between the French and the USA populations. Therefore, Brown and Walker (Brown and Walker, 2008) propose a more accurate conceptualization of vulnerability to heat stress, which they define as a reduction in capacity to adapt to hot weather and/or exposure to heat due to existing social and contextual factors. As a social determinant of health, housing clearly plays a role in the susceptibility of the target group to climatic conditions and in planned adaptive strategies by government, the community and families. Yet very little research has explored how housing and other such social determinants of health may moderate vulnerability in certain population groups and hence contribute to or reduce vulnerability to heat stress. This situation requires research and methods that aim to understand how householders' daily lives and everyday routines are implicated in the creation and reproduction of vulnerability and how these factors can be modified to contribute to their adaptive capacity. This approach will identify alternative pathways to adaptation that are not necessarily dependent on technological solutions or top-down interventions such as the universal adoption of air-conditioning. In particular, the outcomes of such research are likely to identify 'ordinary' heat adaptive strategies that may otherwise go unrecognized.

DISCIPLINES, METHODOLOGIES AND A WAY FORWARD

The disciplinary background of the required research would benefit from drawing on public health as well as sociology and housing research. Both housing and health are multidimensional concepts and are not located within traditional disciplinary (and sectoral) boundaries (Lawrence, 2004). Internationally and in Australia, research on heat stress has relied upon traditional public health approaches such as large-scale epidemiological studies. Although these studies are inherently valuable and have established important groundwork enabling cross-country comparisons, they focus on who is vulnerable using mortality and morbidity data in an emergency management frame; they are therefore less useful in understanding the complexities of broader health and housing issues. Further, they do not provide in-depth 'on-the-ground' data relating to the settings of everyday life and how vulnerability is experienced in a real world context. This gap in knowledge has been recognized by Brown and Walker [(Brown and Walker, 2008), p. 370] who state: '... the understandings that need to be developed have to be cognisant of the particularities of culture, built form, social organization and social expectation that contribute to the production of vulnerability in context, rather than in the abstract'. The findings from such studies will provide insight into detailed adaptation opportunities that will enhance understanding of how to improve the adaptive capacity of a large range of population sub-groups.

The key concept underlying the research should be the interaction between housing and

health (discussed by Lawrence, 2004), framed within a climate change adaptation context.

Established concepts from health promotion, including taking a 'settings' approach (World Health Organization, 1986), and the concepts of vulnerability and adaptation should overlay this interaction and guide the research. However, a new methodology for understanding adaptation to heat will be required. Social practice theory is emerging as a significant modern social theory. Drawing on the work of Bourdieu (Bourdieu, 1990), Giddens (Giddens, 1984) and other contemporary sociologists such as Shove (Shove, 2003a) practice theory concerns the dynamic interactions ('practices') between individuals and wider systems of power, infrastructure, technologies and society (Reckwitz, 2002). A practice is a routinized behaviour which involves connected elements, such as bodily activities, mental activities, things, knowledge, skills, emotion and motivational knowledge (Reckwitz, 2002).

Rather than analysing individual behaviours, practice theorists study widespread, replicated and evolving practices carried out by multiple actors across time and space. Examples of practices are showering, cleaning or achieving thermal comfort. Because it enables exploration of the dynamic interaction with the material environment, infrastructures, technology and social and cultural systems, social practice theory, particularly the work of Shove (Shove, 2003b, 2003a; Shove *et al*., 2008) and Reckwitz (Reckwitz, 2002) would be particularly useful. Further, a social practices approach automatically connects up and accounts for components of complex systems implicated in the creation and maintenance of problems such as mortality and morbidity caused by heat stress, seeing these as the building blocks of the practice itself.

Social and contextual factors such as housing design, neighbourhood planning and the provision of essential services such as energy and water, would feature in research of this nature. For example, increasing use of air-conditioning by households to achieve thermal comfort would not be viewed as a set of individual preferences and 'needs', but as a complex, dynamic and changing process of interrelated technologies, housing infrastructures, thermal comfort standards and social understandings of hygiene, cosiness and comfort, as found by Strengers (Strengers, 2010), Gram-Hanssen (Gram-Hanssen, 2008, 2010) and Chappells and Shove (Chappells and Shove, 2005). The research methodology would focus not only on how householders feel and perceive heat, but rather *why* and *how* they moderate the effects of heat, and what institutional, technical and other system dynamics feature in these activities.

A further conceptual and methodological shift would be to focus on the *practices* people engage in to moderate their vulnerability to heat, rather than their *individual* preferences, attitudes, opinions and physiological variables. Practices of interest would include preparation in advance for hot weather, ensuring availability and increasing intake of fluids, using technologies and artefacts other than the air-conditioner, adjusting housing infrastructures such as windows, blinds and shading, changing clothing and bedding arrangements, using water to cool the body, moving around the house or property, seeking assistance from friends, neighbours and family members, changing physical activity and seeking communally air-conditioned spaces (e.g. libraries, shopping centres; Strengers, 2009). Research such as this, that is designed to understand householders' day-to-day thermal comfort practices, particularly during short-term extremes of heat, could potentially isolate key social and contextual factors that moderate vulnerability. Once identified, these factors could facilitate greater understanding of mortality and morbidity patterns observed in large-scale epidemiological studies, as well as contribute to the design of programmes and policies aiming to increase the adaptive capacity of households to extremes of heat, and rising temperatures more generally.

CONCLUSIONS

Developing a practice-based methodology to understand adaptation to extreme heat will provide a multidimensional, systems-oriented understanding of vulnerability and adaptation. Such an approach will account for components of complex systems implicated in the creation and maintenance of vulnerability to heat stress (e.g. housing type, energy provision), and the relation between different sets of practices (such as the decline in the use of water to achieve comfort and the rise in air-conditioned cooling practices). Without this research agenda, there is a risk that 'one-size-fits-all' technical-fix solutions such as air-conditioning will dominate. If this is the case, householders

may be left *more* vulnerable to heat stress if blackouts ensue from rising peak electricity demand (predominately caused by air-conditioning usage on hot days). Furthermore, such strategies are likely to exacerbate heat-related events in the longer term, by contributing to climate change.

In the short term, outcomes from the agenda for research proposed here would build on existing climate change adaptation and heat stress research, not only increasing capacity for further work in this area but also in terms of contributing to and expanding existing international knowledge about the social and contextual dimensions of vulnerability. The benefits for policy-makers, planners and the health, housing and environment industries generally, would be numerous, including provision of evidence for how existing housing occupied by vulnerable populations performs during periods of extreme heat; increased understanding of the adaptive capacity of vulnerable population groups and where existing and future housing and other policies and programmes can be most effectively targeted; identification of adaptive strategies that may have broad relevance to a large cross-section of the community and; potential identification of alternative strategies than those energy intensive-cooling technology. In the long term, such research may contribute to decreased reliance on air-conditioning (reducing household energy demand/expenses, associated greenhouse gas emissions and peak electricity demand) and improve the overall health and wellbeing of vulnerable households.

ACKNOWLEDGEMENTS

The authors thank two anonymous reviewers as well as Terry Hartig and Johanna Lees for their insightful comments on an earlier draft of this paper.

FUNDING

This research was supported by the Sustainable Urban and Regional Futures Program, Global Cities Institute, RMIT University.

REFERENCES

ABS (2008) Environmental Issues: Energy Use and Conservation (4602.0.55.001).

AMA (2010) Cooling subsidies needed to protect elderly in heat http://www.amavic.com.au/page/Media/Media_Releases/2010/Cooling_subsidies_needed_to_ protect_elderly_in_heat/&rtemplate=1506 (last accessed 22 February 2010).

Borrell, C., Marí-Dell'Olmo, M., Rodriguez-Sanz, M., Garcia-Olalla, P., Cayla, J. A., Benach, J. *et al.* (2006) Socioeconomic position and excess mortality during the heat wave of 2003 in Barcelona. *European Journal of Epidemiology*, **21**, 633–640.

Bouchama, A., Dehbi, M., Mohamed, G., Matthies, F., Shoukri, M. and Menne, B. (2007) Prognostic factors in heat wave related deaths: a meta-analysis. *Archives of Internal Medicine*, **167**, 2170–2176.

Bourdieu, P. (1990) Structures, habitus, practices. In Elliot, A. (ed), *Contemporary Social Theory*. Blackwell Publishers, Ltd., United States.

Brown, S. and Walker, G. (2008) Understanding heat wave vulnerability in nursing and residential homes. *Building Research & Information*, **36**, 363–372.

Chapman, R., Howden-Chapman, P., Viggers, H., O'Dea, D. and Kennedy, M. (2009) Retrofitting houses with insulation: a cost-benefit analysis of a randomised community trial. *Journal of Epidemiology Community Health*, **63**, 271–277.

Chappells, H. and Shove, E. (2005) Debating the future of comfort: environmental sustainability, energy consumption and the indoor environment. *Building Research and Information*, **33**, 32–40.

Confalonieri, U., Menne, B., Akhtar, R., Ebi, K. L., Hauengue, M., Kovats, R. S. *et al.* (2007) Human health. In Parry, M. L., Canziani, O. F., Palutikof, J. P., van der Linden, P. J. and Hanson, C. E. (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 University Press, Cambridge, UK, pp. 391–431.

de Dear, R. J. and Brager, G. S. (2002) Thermal comfort in naturally ventilated buildings: revisions to ASHRAE Standard 55. *Energy and Buildings*, **34**, 549–561.

DEWHA (2008) *Energy Use in the Australian Residential Sector 1986–2020*. Australian Government: Department of the Environment, Water, Heritage and the Arts (DEWHA), Canberra, ACT.

DPI (2009) Energy: Providing Sufficient Capacity. Retrieved 18 June, 2009, from http://www.dpi.vic.gov.au/DPI/dpinenergy.nsf/childdocs/ 3F827E74C37E0836CA25729D00101EB0- F1FE5D56C92AAD05CA2572B200162BB7?open.

EES (2006) *Status of Air Conditioners in Australia—Updated with 2005 Data*. Energy Efficient Strategies prepared for the National Appliance and Equipment Energy Efficiency Committee (NAEEEC), Canberra, ACT.

Evans, G. W., Wells, N. M. and Moch, A. (2003) Housing and mental health: a review of the evidence and a methodological and conceptual critique. *Journal of Social Issues*, **59**, 475–500.

Frumkin, H., McMichael, A. J. and Hess, J. J. (2008) Climate change and the health of the public. *American Journal of Preventive Medicine*, **35**, 401–402.

Giddens, A. (1984) *The Constitution of Society: Outline of the Theory of Structuration*. Polity Press, Cambridge.

Gram-Hanssen, K. (2008) Consuming technologies—developing routines. *Journal of Cleaner Production*, **16**, 1181–1189.

Gram-Hanssen, K. (2010) Residential heat comfort practices: understanding users. *Building Research and Information*, **38**, 175–186.

Harlan, S. L., Brazel, A. J., Prashad, L., Stefanov, W. L. and Larsen, L. (2006) Neighborhood microclimates and vulnerability to heat stress. *Social Science & Medicine*, **63**, 2847–2863.

Hennessy, K., Fitzharris, B., Bates, B. C., Harvey, N., Howden, M., Hughes, L. *et al.* (2007) Australia and New Zealand. In Parry, M. L., Canziani, O. F., Palutikof, J. P., Linden, P. J. v. d. and Hanson, C. E. (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 University Press, Cambridge, UK, pp. 507–540.

Howden-Chapman, P. (2004) Housing standards: a glossary of housing and health. *Journal of Epidemiology Community Health*, **58**, 162–168.

Kelly, P. and Adger, W. (2000) Theory and practice in assessing vulnerability to climate change and facilitating adaptation. *Climatic Change*, **47**, 325.

Klinenberg, E. (2002) *Heat Wave: A Social Autopsy of the Disaster in Chicago*. University of Chicago Press, Chicago.

Lawrence, R. J. (2004) Housing and health: from interdisciplinary principles to transdisciplinary research and practice. *Futures*, **36**, 487–502.

McMichael, A. J. (2009) Chapter 1: climate change and human health. In *Commonwealth Health Ministers' Update 2009*. Commonwealth Secretariat, Canberra, Australia, pp. 11–20.

McMichael, A. J. and Githeko, A. (2001) Human Health. In McCarthy, J. J., Canziani, O. F., Leary, N. A., Dokken, D. J. and White, K. S. (eds), *Climate Change 2001: Impacts, Adaptation, and Vulnerability: Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, pp. 453–485.

McMichael, A. J., Weaver, H. J., Berry, H., Beggs, P. J., Currie, B., Higgins, J. *et al.* (2008) *Human Health and Climate Change: National Adaptation Research Plan*. National Climate Change Adaptation Research Facility, Canberra, ACT.

Nicol, F. and Roaf, S. (2007) Progress on passive cooling: adaptive thermal comfort and passive architecture. In Santamouris, M. (ed), *Advances in Passive Cooling*. Earthscan, London, UK, pp. 1–29.

OECD (2002) *Towards Sustainable Household Consumption? Trends and Policies in OECD Countries*. Organisation of Economic Co-operation and Development (OECD), France.

Reckwitz, A. (2002) Toward a theory of social practices: a development in culturalist theorizing. *European Journal of Social Theory*, **5**, 243–263.

Rey, G., Fouillet, A., Bessemoulin, P., Frayssinet, P., Dufour, A., Jougla, E. *et al.* (2009) Heat exposure and socio-economic vulnerability as synergistic factors in heat-wave-related mortality. *European Journal of Epidemiology*, **24**, 495–502.

Santamouris, M. (2007) Preface: why passive cooling? In Santamouris, M. (ed), *Advances in Passive Cooling*. Earthscan, London, UK, pp. xx–xxxii.

Shove, E. (2003a) *Comfort, Cleanliness and Convenience—The Social Organization of Normality*. Berg, Oxford.

Shove, E. (2003b) Users, technologies and expectations of comfort, cleanliness and convenience. *Innovation: The European Journal of Social Science Research*, **16**, 193–206.

Shove, E., Chappells, H., Lutzenhiser, L. and Hackett, B. (2008) Comfort in a lower carbon society. *Building Research & Information*, **36**, 307–311.

Smoyer, K. E. (1998) A comparative analysis of heat waves and associated mortality in St. Louis, Missouri—1980 and 1995. *International Journal of Biometeorology*, **42**, 44–50.

Strengers, Y. (2008) Comfort expectations: the impact of demand-management strategies in Australia. *Building Research & Information*, **36**, 381–391.

Strengers, Y. (2009) Bridging the divide between resource management and everyday life: smart metering, comfort and cleanliness. PhD. Thesis. *School of Global Studies, Social Science and Planning*. RMIT University, Melbourne, VIC.

Strengers, Y. (2010) Air-conditioning Australian households: a trial of Dynamic Peak Pricing. *Energy Policy*, **38**, 7312–7322.

Vandentorren, S., Bretin, P., Zeghnoun, A., Mandereau-Bruno, L., Croisier, A., Cochet, C. *et al.* (2006) August 2003 heat wave in France: risk factors for death of elderly people living at home. *European Journal of Public Health*, **16**, 583–591.

Wilkenfeld, G. (2004) *A National Demand Management Strategy for Small Airconditioners: the Role of the National Appliance and Equipment Energy Efficiency Program (NAEEEP)*. George Wilkenfeld and Associates for the National Appliance and Equipment Energy Efficiency Committee (NAEEEC) and the Australian Greenhouse Office, Sydney, NSW.

Wilkenfeld, G. (2007) *Options to Reduce Greenhouse Emissions from New Homes in Victoria through the Building Approval Process*. George Wilkenfeld and Associates with Energy Efficient Strategies for the Department of Sustainability and Environment, Sydney, NSW.

Williamson, T. J., Coldicutt, S. and Penny, R. E. C. (1991) *Thermal Preferences in Housing in the Humid Tropics (ERDC Report No.1)*. Energy Research and Development Corporation, Canberra, ACT.

World Health Organization (1986) Ottawa Charter for Health Promotion. In *International Conference on Health Promotion: The Move Towards a New Public Health*, World Health Organization, Health and Welfare Canada, Canadian Public Health Association, Ottawa.