

Strategies to Mitigate the Impacts of Extreme Heat Events  
Among Homeless Populations in BC's Lower Mainland: A  
Review of Evidence-Based Approaches and Recommendations

by

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# Summary

## *Introduction*

- Climate change has led to an increase in extreme heat events (EHE) in Canada and globally, which are directly associated with morbidity and mortality.
- Homeless populations are particularly vulnerable to the health effects of EHE due to a combination of broad risk factors.

## *Methods*

- To examine the current state of knowledge on ways to mitigate the risks of EHE in academic literature, twenty-three studies from five databases were reviewed.
- Studies that shared similar contexts, research questions, study designs, methodologies, health outcomes and/or program plans were then thematically grouped into sub-disciplines of research for analysis.

## *Results and Discussion*

- Five main themes emerged from the studies that were returned from the database searches: 1) the usefulness of geospatial mapping to identify EHE hotspots and vulnerable populations, 2) the paucity of complete and/or adequate data for surveillance of heat-related morbidities and mortalities, 3) the inclusion of social and economic factors in EHE studies is integral to understanding and addressing each community's unique needs, 4) the importance of built environment features in long-term mitigation of and adaptation to EH impacts, and 5) the alignment of multiple stakeholders' perceptions on the risks associated with extreme heat exposure is crucial for effective coordination of EHE responses and evaluation.
- Most publications lacked an in-depth examination of strategies to address homeless people's specific health needs.
- Opportunities and challenges around data limitations, inconsistent definitions of heat-related illnesses and deaths, as well as analytical gaps in EHE research and practice were explored.

## *Conclusions*

- This capstone project proposes eight recommendations for Health Authorities in BC's Lower Mainland to reduce the impacts of EHE on the homeless population.
- Priority action items include but are not limited to: the involvement of homeless people in intervention dialogues; the increase in the availability of and accessibility to cooling spaces; the enhancement of health service delivery for homeless people; and the improvement of data gathering practices to facilitate surveillance and evaluation.

# 1. Introduction

Since the mid-twentieth century, the synergistic occurrence of natural factors and anthropogenic activities has accelerated climate change in Canada and globally (1,2). The key drivers of changing climate patterns over time can be attributed to rising greenhouse gas emissions through the burning of fossil fuels and changes in land-use patterns (1,2). In the past century alone, global temperatures have risen by 0.8 degrees Celsius or 1.4 degrees Fahrenheit (3). Furgal *et al.* as cited by Lemmen *et al.* (2) stated that at the individual level the direct impacts of more extreme hot weather (EHW) pertain to increases in heat-related morbidity and mortality. EHW also has indirect consequences, namely increases in the incidence and transmission patterns of infectious diseases, as well as changes in a person's psychosocial wellbeing (2). These direct and indirect health outcomes of climate change should be of concern to the scientific community.

## 1.1 – Extreme Heat Events

According to the United States Environmental Protection Agency (USEPA), as cited by the US Centers for Disease Control and Prevention (4), extreme heat events (EHE) are characterized by “summertime weather that is substantially hotter and/or more humid than average for a location at that time of year” (p.3). Climate models have projected that EHE will increase in frequency, magnitude and duration sooner rather than later (2,3).

Common illnesses associated with extreme heat (EH) are heat edema, heat rash, heat cramps, fainting, heat exhaustion, and in severe cases, heat stroke, which could be fatal (5). EH can also aggravate certain health conditions, particularly those that are cardiovascular and

respiratory in nature (4). Thus, excess heat can be considered as a toxic exposure to human health. Its acute and unexpected onset also renders it as a “silent killer” (6).

## **1.2 – Target Population**

The focus of this capstone project will be on absolutely homeless populations who are street-entrenched (8). Several factors associated with living in a street environment exacerbate their vulnerability to EHE, which more privileged members of society do not experience in isolation or concomitantly. These include exposure to the outside environment with minimal protection; compromised physiological functions; reliance on active travel to reach places; inadequate access to water; malnourishment; the early onset of geriatric conditions; clustering in urban cores with urban heat islands; the lack of social networks for support and financial means to seek health resources; and for many, challenges related to mental illness and/or substance use problems (3,7, 9-18) – all of which have health repercussions.

## **1.3 – Background**

The City of Vancouver, which is served by Vancouver Coastal Health Authority (VCHA), was the first municipality in British Columbia (BC) to initiate a Hot Weather Preparedness and Response Plan in 2010 (19). Other municipalities have begun to follow Vancouver’s footsteps and develop their own local EHE responses, namely the Cities of Abbotsford and Pitt Meadows under Fraser Health Authority (FHA), albeit on a small-scale.

However, a policy scan revealed that the rest of the communities in the Lower Mainland have yet to develop their own hot weather plans. This is a significant gap in terms of providing homeless populations with health and support services during EHW. Therefore, a critical

investigation of evidence-based approaches is warranted to expand on existing programs and to provide regional Health Authorities with guidelines to reach and work with other communities where heat response plans are lacking.

#### **1.4 – Purpose**

This capstone project seeks to address the following research questions: What is the current state of knowledge on ways to mitigate the risks of EHE in the peer-reviewed literature? What strategies could be incorporated by Health Authorities in the Lower Mainland region of BC to reduce the impacts of extreme heat events on the homeless population?

## **2. Methods**

Twenty-three articles were reviewed from five databases to address the research question stated above (see Appendix A). The information derived from these academic sources was then critically reviewed as evidence that can support the development of EHE mitigation strategies for homeless populations that Health Authorities in BC can uptake. Information on common contexts, research questions, study designs, methodologies, health outcomes and program plans was extracted from each article. Studies that shared one or more of these elements were then thematically grouped into sub-disciplines of research for analysis.

## **3. Results and Discussion**

Albeit most publications acknowledged that homeless people are among the most vulnerable sub-populations to the impacts of EHE, an in-depth and focused discussion of

strategies to address this group's specific health needs was considerably lacking. Very few studies directly investigated the impacts of climate change on the health of the homeless. This itself was a crucial finding for the communities of research and public health practice. However, five main themes emerged from the studies that were returned from the database searches.

### **3.1 – Geospatial Mapping**

Geospatial mapping has been used in EHE studies and their subsequent impacts on human health in the USA, particularly in states with dry and arid climates. Uejio *et al.* (20) and Eisenman *et al.* (21) both used ecological spatial analysis in Maricopa County, Arizona (and Philadelphia, Pennsylvania for the former) to study heat mortality using indicators involving building characteristics, socioeconomic vulnerability, and neighbourhood stability. Fraser *et al.* (15) also used this technique to determine inequities in private and public cooling resource access in Los Angeles, California and Maricopa County.

In Melbourne, Australia, Loughnan, Nicholls and Tapper (22) generated heat vulnerability maps in Melbourne using an index with environmental, health and demographic variables. In Arad, Romania, Papatoma-Koehle *et al.* (23) applied a risk assessment methodology to generate hazard and impact maps of heat vulnerability. Aminipouri, Knudby and Ho (24) used three indicators to also map heat vulnerability in Vancouver at the census dissemination area (DA) level. Such advances in software and modelling techniques have offered public health practitioners with promise in preventing heat-related illnesses and fatalities.

### **3.2 – Surveillance Data**

The need for a strong surveillance system in Canada became event after Koutsavlis and Kosatsky (25) assessed that most cold-weather related environmental-temperature injuries occurred at a rate of 3.1 per 100,000 person years, and deaths at 0.3 per 100,000 person years on Montreal Island in 1999. Similarly, Coates, Haynes, O'Brien, McAneney and de Oliveria's (26) estimated from heat deaths coded using different nomenclature over time in Australia that 5,332 people died due to EHE from 1844 to 2010. Likewise, Johnson *et al.* (27) linked vital statistics and medical examiner data from 1990 to 2011 in Oklahoma and found 364 confirmed and probable heat-related deaths. In another study, heat-stress calls increased dramatically when temperatures exceeded 35 degrees Celsius in the Chicago and 45 degrees Celsius in Phoenix, indicating that people in Chicago are less acclimatized to EH (28). Further, Chen *et al.* (29) found that non-accidental deaths increased by 2.5% (that is, four excess deaths) without lag time per 5-degree Celsius increase in daily mean temperatures between June and August in Ontario.

One health care resource typically accessed by disadvantaged populations such as the homeless is emergency departments (ED) (30). Data from ED can be supplemented by information from paramedic and emergency medical systems to facilitate real-time reporting of cases (30), potentially capturing more homeless peoples' experiences for surveillance and program planning.

### **3.3 – Social and Economic Factors**

The literature strongly suggests that researchers and other institutional bodies recognize the interplay between macro-level social determinants of health and the incidence of heat illness and mortality. However, Yardley, Sigal and Kenny (31) suggested that the pathways through

which these broader social factors aggravate or mitigate risks due to EHE are poorly understood, as demonstrated by diverse hypotheses that authors have presented.

Loughnan *et al.* (22) found that the proportion of aged care facilities, ethnicity, households with single persons over 65 years old, areas with a large proportion of persons in the age groups of 0-4 years old and 65 plus, and urban density were significantly correlated with the spatial distribution of their vulnerability index. Other studies have also shown that factors associated with social vulnerability, such as poverty, social and linguistic isolation, are positively associated with greater heat distress calls (HDC) and heat mortality (20,21,24,32). In addition, Harlan, Deplet-Barreto, Stefanov and Petitti (32) geocoded places of injury from death certificates as a proxy for street addresses for 50 individuals presumed to be homeless and found that deaths occurred mostly in inner-city high vulnerability areas (32).

Investigations of homeless people's behaviours can also be used to guide EHE studies when detailed information is not available. For example, Karner, Hondula and Varnos (33) found that low-income individuals and other vulnerable populations were more likely to be exposed to EH through non-motorized travel. This can be applied to homeless populations because homeless people mainly rely on walking to travel (14).

### **3.4 – Built Environment Features**

Fraser *et al.* (15) reported that accessibility to cooling resources decreases from urban to suburban areas, which could be due to decreasing parcel and intersection densities, and increasing land use homogeneity. After controlling for social vulnerability, Eisenman *et al.* (21) found that more publicly available cooling spaces was negatively associated with heat-related illness as maximum temperature increases. These results are consistent in Vancouver, where



Aminipouri *et al.* (24) found that DAs with populations highly vulnerable to EHE had low vegetation, were exposed to hot surface temperatures, not close to cooling and health infrastructure, and had environments where heat exposure was elevated.

In another Canadian study, Graham, Vanos, Kenny and Brown (34) found that census tracts which saw a marginal increase of tree cover from 0% to 5% had 80% fewer ambulance calls, while a 75% decrease in ambulance calls was observed when hard surface cover proportion decreased from more than 75% to 70-75% (34). Harlan *et al.* and Klein Rosenthal, Kenney and Metzger (32,35) arrived at comparable results, as they found that impervious land cover was a predictor of a greater odds of mortality.

### **3.5 – Aligning Perspectives on EHE Risks and Responses**

The largest barrier to effectively coordinate activities to mitigating the impacts of EHE is the lack of awareness on the unique and complex needs of the homeless among stakeholders who have the capacity to address them. Ramin and Svoboda (7) reported that up until recently no papers had delved into this inquiry of the effects of climate change on the homeless due to a lack of systematically collected data for epidemiological evidence.

In 2013, Cusack, van Loon, Kralik, Arbon, and Gilbert (36) conducted a qualitative study on the needs of the homeless in Adelaide, Australia, confirming the challenges on service providers' end to respond to homeless individuals' health needs due to limited resources, and on that of homeless individuals as they struggle with discrimination in health and social settings. This is concerning because not all homeless people are aware of the dangers of EHE (37).

Schuch, Serrao-Neumann and Choy (38) also found that vulnerable groups in a community do not appear to be engaged or involved at all in heatwave management planning.

Bassil and Cole (39) found that awareness of heat events and alerts is universal in the public, but this is not reflected in practice when responding to EHE. In contrast, Schuch *et al.* (38) found that perceptions of heatwaves were not consistent among the stakeholders that they interviewed. Zuo *et al.* (40) concluded that a greater focus is needed on understanding the cultural and behavioural implications of structural and technological mechanisms to adequately mitigate EHE impacts on vulnerable populations.

### **3.6 – Strengths and Limitations**

#### **3.6.1. Data Limitations**

While a visual representation of EHE and potential intervention hotspots may be appealing to policy makers, it can be challenging to map variables that speak to the socioeconomic context of a place such as health status, as these data are either difficult to obtain, are protected for confidentiality reasons, or are not available in spatial format (23). Although many Canadian sources contain rich population-level data, the absence of a spatial format and data specific to DAs within smaller municipalities can be barriers to mapping analyses.

Nevertheless, geospatial mapping is cost-effective analytical tool (21), which merely requires computer software, access to adequate datasets, and working with researchers with technical and analytical skills. Even with preliminary findings, this strategy could be most beneficial to municipalities where heat warning systems and response programs have yet to be developed (20), such as the majority of communities in the Lower Mainland.

### ***3.6.2. Inconsistent Definitions of Heat-Related Illnesses and Deaths***

Cases might be underestimated due to inconsistent definitions of what constitutes a heat-related illness or death across different time periods and between several data sources (25,26). Koutsavlis and Kosatsky (25) also recognized that their hospital data did not include patients who sought medical care from physicians in emergency rooms without admission, as well as community resources, which people are more likely to access with less serious environmental injuries. Moreover, cases may be underestimated due to errors in diagnostic practices (25).

### ***3.6.3. Analytical Gaps***

The lack of sufficient spatial data on the homeless population prevented Aminipouri *et al.* (24) from including this group in their analysis of heat vulnerability and HDCs, which may have underestimated the impacts of EHE. Homeless people may have also been underrepresented in Uejio *et al.*'s (20) study, as they are less likely to have access to telephone service. Their transient nature may have led to misclassification bias because locations of HDC may not align with the neighbourhood where they were originally censused (20).

However, finding ways to adequately study morbidity and mortality patterns among homeless people is not an impossible task, as shown by Harlan *et al.*'s (32) work. There is also value in current research that may not directly involve homeless people, as findings can inform upstream policies and actions that may protect other vulnerable groups from homelessness.

## **4. Conclusions**

The progression of climate change will be evident for many decades, and perhaps even centuries (2). Absolutely homeless populations in the Lower Mainland are particularly prone to

the effects of EHE as climate change continues. Yet, this group is evidently ignored in academic literature on EHE and health despite existing notions that the best interventions to a public health problem are evidence-based.

The findings of the literature review from existing studies on EHE revealed five areas to explore. Eight recommendations are presented below to create policies and programs that can bridge the gaps between evidence and practice in the mitigation of EHE. These should be considered as priority action items in preparation for EHEs in the Lower Mainland:

- Establish formal partnerships between VCHA, FHA, the BC Centre for Disease Control, and BC Housing to up-scale existing EH programs and guide the development of EHW response programs where needed;
- Involve homeless people in intervention dialogues;
- Create a consistent alert protocol across Health Authorities;
- Increase the availability of and accessibility to cooling spaces;
- Enhance health service delivery for homeless people;
- Increase outreach services and communication with homeless populations;
- Improve data gathering practices to facilitate surveillance and evaluation; and
- Explore higher-level policy changes for the health of communities.

The potential solutions presented here are a non-exhaustive list of the possible ways to address EHE. Rather, these are steps that can be taken by stakeholders in the community, such as local Health Authorities, who share a common vision of a healthier, greener future for themselves and others, including those who are disadvantaged in the interim. Future analyses should consider longer-term solutions to mitigating and adapting to the impacts of not just EHE, but all the ramifications of climate change.

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## References

- (1) Intergovernmental Panel on Climate Change. *Climate Change 2007: The Physical Science Basis*. 2007; Available from: [https://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4\\_wg1\\_full\\_report.pdf](https://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4_wg1_full_report.pdf)
- (2) Lemmen DS, Warren FJ, Lacroix J, Bush E. *From Impacts to Adaptation: Canada in a Changing Climate 2007*. Ottawa, ON: Government of Canada. 2008; Available from: [https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/assess/2007/pdf/full-complet\\_e.pdf](https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/assess/2007/pdf/full-complet_e.pdf)
- (3) Health Canada. *Heat Alert and Response Systems to Protect Health: Best Practices Guidebook*. 2012; Available from: [http://www.hc-sc.gc.ca/ewh-semt/alt\\_formats/pdf/pubs/climat/response-intervention/response-intervention-eng.pdf](http://www.hc-sc.gc.ca/ewh-semt/alt_formats/pdf/pubs/climat/response-intervention/response-intervention-eng.pdf)
- (4) US Centers for Disease Control and Prevention. *Climate Change and Extreme Heat Events*. n.d.; Available from <https://www.cdc.gov/climateandhealth/pubs/ClimateChangeandExtremeHeatEvents.pdf>
- (5) Government of Canada. *Extreme heat: heat waves*. 2012; Available from: <https://www.canada.ca/en/health-canada/services/sun-safety/extreme-heat-heat-waves.html#b1>
- (6) Canadian Environmental Health Atlas. *Heat Waves*. n.d.; Available from: <http://www.ehatlas.ca/key-points/90>
- (7) Ramin B, Svoboda T. Health of the homeless and climate change. *J Urban Health*. 2009;86(4): 654-664. Available from: doi:10.1007/s11524-009-9354-7
- (8) Girard MC. Determining the Extent of the Problem: The Value and Challenges of Enumeration. *CRSP*. 2006;58: 101-107. Available from [file:///Users/edre necabantog/Downloads/out%20\(1\).pdf](file:///Users/edre necabantog/Downloads/out%20(1).pdf)
- (9) Clean Air Partnership. *Climate Change Adaptation and Health Equity: Background Report*. 2011; Available from: [http://www.climateontario.ca/doc/ORAC\\_Products/TPH/Climate%20Change%20Adaptation%20and%20Health%20Equity%20-%20Background%20Report.pdf](http://www.climateontario.ca/doc/ORAC_Products/TPH/Climate%20Change%20Adaptation%20and%20Health%20Equity%20-%20Background%20Report.pdf)

- (10) Government of Canada. *First aid advice for sunburn and heat illness*. 2012; Available from: <https://www.canada.ca/en/health-canada/services/sun-safety/first-aid-advice-sunburn-heat-illness.html>
- (11) Canadian Red Cross. *Heat-Related Emergencies: Staying Cool and Hydrated During Canadian Summer*. 2016; Available from: <http://www.redcross.ca/training-and-certification/first-aid-tips-and-resources/first-aid-tips/heat-related-emergencies--staying-cool-and-hydrated-in-canadian-summers>
- (12) United States Environmental Protection Agency. *Excessive Heat Events Guidebook*. 2006; Available from: [https://www.epa.gov/sites/production/files/2016-03/documents/ehguide\\_final.pdf](https://www.epa.gov/sites/production/files/2016-03/documents/ehguide_final.pdf)
- (13) The Homeless Hub. *Concurrent Disorders*. 2017; Available from: <http://homelesshub.ca/about-homelessness/substance-use-addiction/concurrent-disorders>
- (14) To MJ, Brothers TD, Van Zoost C. Foot Conditions among Homeless Persons: A Systematic Review. *PLoS ONE*. 2006;11(12): e0167463. Available from: doi:10.1371/journal.pone.0167463
- (15) Fraser AM, Chester MV, Eisenman D, Hondula DM, Pincetl SS, English P, Bondank E. Household accessibility to heat refuges: Residential air conditioning, public cooled space, and walkability. *Env Plann B Plann Des.* 2016;0(0): 1-20. Available from: doi: 10.1177/0265813516657342
- (16) Wiecha JL, Dwyer JT, Dunn-Strohecker M. Nutrition and health services needs among the homeless. *Public Health Rep.* 1991;106(4): 364-374. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1580272/>
- (17) Brown RT, Hemati K, Riley ED, Lee CT, Ponath C, Tieu L et al. Geriatric Conditions in a Population-Based Sample of Older Homeless Adults. *Gerontologist*. 2016;(00)00: 1-10. Available from: doi:10.1093/geront/gnw011
- (18) Lee RA, Schreck CJ. Danger on the Streets: Marginality and Victimization Among Homeless People. *Am Beh Sci*. 2005;48(8): 1055-1081. Available from: <http://journals.sagepub.com.proxy.lib.sfu.ca/doi/pdf/10.1177/0002764204274200>
- (19) City of Vancouver. *Review of Preparedness and Response Services During Extreme Weather*. 2010; Available from <http://council.vancouver.ca/20100706/documents/rr1.pdf>

- (20) Uejio CK, Wilhelmi 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(2): 498-507. Available from: doi:<http://dx.doi.org.proxy.lib.sfu.ca/10.1016/j.healthplace.2010.12.005>
- (21) Eisenman DP, Wilhalme H, Tseng C, Chester M, English P, Pincetl S et al. Heat death associations with the built environment, social vulnerability and their interactions with rising temperature. *Health Place*. 2016;41: 88-99. Available from: doi:<http://dx.doi.org.proxy.lib.sfu.ca/10.1016/j.healthplace.2016.08.007>
- (22) Loughnan M, Nicholls N, Tapper NJ. Mapping heat health risks in urban areas. *Int J Popul Res*; 2012: 1-12. Available from: doi: <http://dx.doi.org.proxy.lib.sfu.ca/10.1155/2012/518687>
- (23) Papathoma-Koehle M, Promper C, Bojariu R, Cica R, Sik A, Perge K, Glade T. A common methodology for risk assessment and mapping for southeast Europe: An application for heat wave risk in Romania. *Nat Hazards*. 2016;82(1): 89-109. Available from: doi:10.1007/s11069-016-2291-3
- (24) Aminipouri M, Knudby A, Ho HC. Using multiple disparate data sources to map heat vulnerability: Vancouver case study. *Can Geogr*. 2016;30(6): 356-368. Available from: doi:10.1111/cag.12282
- (25) Koutsavlis AT, Kosatsky T. Environmental-temperature injury in a Canadian metropolis. *J Env Health*. 2003;66(5): 40-45. Available from: <http://proxy.lib.sfu.ca/login?url=http://search.ebscohost.com.proxy.lib.sfu.ca/login.aspx?direct=true&db=a9h&AN=11571640&site=ehost-live>
- (26) Coates L, Haynes K, O'Brien J, McAneney J, de Oliveira FD. Exploring 167 years of vulnerability: An examination of extreme heat events in Australia 1844–2010. *Env Sci Pol*. 2014;42: 33-44. Available from: doi:<http://dx.doi.org.proxy.lib.sfu.ca/10.1016/j.envsci.2014.05.003>
- (27) Johnson MG, Brown S, Archer P, Wendelboe A, Magzamen S, Bradley KK. Identifying heat-related deaths by using medical examiner and vital statistics data: Surveillance analysis and descriptive epidemiology — Oklahoma, 1990–2011. *Env Res*. 2016;150 30-37. Available from: doi:<http://dx.doi.org.proxy.lib.sfu.ca/10.1016/j.envres.2016.05.035>



- (28) Chuang W, Gober P, Chow, WTL, Golden J. Sensitivity to heat: A comparative study of Phoenix, Arizona and Chicago, Illinois (2003–2006). *Urban Climate*. 2013;5: 1-18. Available from: doi:<http://dx.doi.org.proxy.lib.sfu.ca/10.1016/j.uclim.2013.07.003>
- (29) Chen H, Wang J, Li Q, Yagouti A, Lavigne E, Foty R et al. Assessment of the effect of cold and hot temperatures on mortality in Ontario, Canada: A population-based study. *CMAJ Open*. 2016;4(1): E48. Available from: doi: 10.9778/cmajo.20150111.
- (30) Rhodes KV, Pollock DA. The future of emergency medicine public health research. *Emerg Med Clin North Am*. 2006;24(4): 1053-73. Available from: [http://repository.upenn.edu/cgi/viewcontent.cgi?article=1108&context=spp\\_papers](http://repository.upenn.edu/cgi/viewcontent.cgi?article=1108&context=spp_papers)
- (31) Yardley J, Sigal RJ, Kenny GP. Heat health planning: The importance of social and community factors. *Glob Environ Chang*. 2011;21(2): 670-679. Available from: doi:<http://dx.doi.org.proxy.lib.sfu.ca/10.1016/j.gloenvcha.2010.11.010>
- (32) Harlan SL, Declat-Barreto J, Stefanov WL, Petitti DB. Neighborhood effects on heat deaths: Social and environmental predictors of vulnerability in Maricopa County, Arizona. *Environ Health Persp*. 2013;121(2): 197-204. Available from: doi:10.1289/ehp.1104625
- (33) Karner A, Hondula DM, Vanos JK. Heat exposure during non-motorized travel: Implications for transportation policy under climate change. *J Transp Health*. 2015;2(4): 451-459. Available from: doi: <http://dx.doi.org.proxy.lib.sfu.ca/10.1016/j.jth.2015.10.001>
- (34) Graham DA, Vanos JK, Kenny NA, Brown RD. The relationship between neighbourhood tree canopy cover and heat-related ambulance calls during extreme heat events in Toronto, Canada. *Urban For Urban Greening*. 2016;20: 180-186. Available from: doi: <http://dx.doi.org.proxy.lib.sfu.ca/10.1016/j.ufug.2016.08.005>
- (35) Klein Rosenthal J, Kinney PL, Metzger KB. Intra-urban vulnerability to heat-related mortality in New York City, 1997–2006. *Health Place*. 2014;30: 45-60. Available from: doi:<http://dx.doi.org.proxy.lib.sfu.ca/10.1016/j.healthplace.2014.07.014>
- (36) Cusack L, van Loon A, Kralik D, Arbon P, Gilbert S. Extreme weather-related health needs of people who are homeless. *Aust J Prim Health*, 2013;19(3): 250-255. Available from doi: 10.1071/PY12048

- (37) Nicolay, M, Brown LM, Johns R, Ialynytchev A. A study of heat related illness preparedness in homeless veterans. *Int J Disaster Risk Reduct.* 2016;18: 72-74. Available from: doi:<http://dx.doi.org.proxy.lib.sfu.ca/10.1016/j.ijdr.2016.05.009>
- (38) Schuch G, Serrao-Neumann S, Choy DL. Managing health impacts of heat in southeast Queensland, Australia. *Disaster Health.* 2014;2(2): 82-91. Available from: doi:<http://dx.doi.org.proxy.lib.sfu.ca/10.4161/2167549X.2014.960717>
- (39) Bassil KL, Cole DC. Effectiveness of public health interventions in reducing morbidity and mortality during heat episodes: A structured review. *Int J Environ Res Public Health.* 2010;7(3): 991-1001. Available from: doi:10.3390/ijerph7030991
- (40) Zuo J, Pullen S, Palmer J, Bennetts H, Chileshe N, Ma T. Impacts of heat waves and corresponding measures: A review. *J Clean Prod.* 2015;92: 1-12. Available from: doi:<http://dx.doi.org.proxy.lib.sfu.ca/10.1016/j.jclepro.2014.12.078>

## Appendix A – Search Strategy

Database	Search Terms	No. of Results
Google Scholar	- “Extreme heat” <i>and</i> “homelessness” <i>and</i> response plans <i>and</i> interventions	236
	- "Heat injury" <i>or</i> "heat toxicity" <i>and</i> "homeless*"	36
Medline (PubMed)	- “Extreme heat” <i>and</i> “homeless*”	3
	- “Climate change” <i>and</i> “homeless*”	8
	- “Heat waves” <i>and</i> “homeless*”	1
Science Direct	- “Extreme heat” <i>and</i> “homelessness”	20
	- “Extreme heat” <i>and</i> “homeless*” <i>and</i> response plans <i>and</i> interventions	23
	- "Heat injury" <i>or</i> "heat toxicity" <i>and</i> "homeless*"	2
CINAHL Complete	- “Extreme heat” <i>and</i> “homeless*”	18
	- “Heat waves” <i>and</i> “homeless*”	15
	- "Heat injury" <i>or</i> "heat toxicity" <i>and</i> "vulnerable populations"	31
Web of Science	- “Extreme heat” <i>and</i> “homeless*”	2
	- “Heat waves” <i>and</i> “homeless*”	3
<b>Total no. of relevant results</b>		<b>398</b>

Inclusion criteria were specified to articles published from 2000 and onwards, written in English, and contained full text. For searches where publications were available, a total of 398 results were returned. Articles’ titles and abstracts were screened for relevance to the topic of EHE and potentially applicable content to homelessness. Out of those that appeared to be relevant in the subsequent screening process, 55 duplicate articles were identified and excluded. The remaining 320 articles were deemed irrelevant to the topic at hand and also excluded. In the end, 23 articles were determined to be of value for further reading.

## Appendix B – Publication details of studies reviewed

Title	Authors	Year Published	Country of Origin
Using multiple disparate data sources to map heat vulnerability: Vancouver case study	Aminipouri, M., Knudby, A., & Ho, H. C.	2016	Canada
Effectiveness of public health interventions in reducing morbidity and mortality during heat episodes: A structured review	Bassil, K. L., & Cole, D. C.	2010	Canada
Assessment of the effect of cold and hot temperatures on mortality in Ontario, Canada: A population-based study	Chen, H., Wang, J., Li, Q., Yagouti, A., Lavigne, E., Foty, R., ... Copes, R.	2016	Canada
Sensitivity to heat: A comparative study of Phoenix, Arizona and Chicago, Illinois (2003–2006)	Chuang, W., Gober, P., Chow, W. T. L., & Golden, J.	2013	USA
Exploring 167 years of vulnerability: An examination of extreme heat events in Australia 1844–2010	Coates, L., Haynes, K., O'Brien, J., McAneney, J. & de Oliveira, F. D.	2014	Australia
Extreme weather-related health needs of people who are homeless	Cusack, L., van Loon, A., Kralik, D., Arbon, P. & Gilbert, S.	2013	Australia
Heat death associations with the built environment, social vulnerability and their interactions with rising temperature	Eisenman, D. P., Wilhalme, H., Tseng, C., Chester, M., English, P., Pincetl, S., ... Dhaliwal, S. K.	2016	USA
Household accessibility to heat refuges: Residential air conditioning, public cooled space, and walkability	Fraser, A. M., Chester, M. V., Eisenman, D., Hondula, D. M., Pincetl, S. S., English, P. & Bondank, E.	2016	USA
The relationship between neighbourhood tree canopy cover and heat-related ambulance calls during extreme heat events in Toronto, Canada	Graham, D. A., Vanos, J. K., Kenny, N. A., & Brown, R. D.	2016	Canada
Neighborhood effects on heat deaths: Social and environmental predictors of vulnerability in Maricopa County, Arizona	Harlan, S. L., Deplet-Barreto, J., Stefanov, W. L. & Petitti, D. B.	2013	USA
Identifying heat-related deaths by using medical	Johnson, M. G., Brown, S., Archer, P., Wendelboe,	2016	USA

examiner and vital statistics data: Surveillance analysis and descriptive epidemiology — Oklahoma, 1990–2011	A., Magzamen, S. & Bradley, K. K.		
Heat exposure during non-motorized travel: Implications for transportation policy under climate change	Karner, A., Hondula, D. M., & Vanos, J. K.	2015	USA
Intra-urban vulnerability to heat-related mortality in New York City, 1997–2006	Klein Rosenthal, J., Kinney, P. L. & Metzger, K. B.	2014	USA
Environmental-temperature injury in a Canadian metropolis	Koutsavlis, A. T. & Kosatsky, T.	2003	Canada
Mapping heat health risks in urban areas	Loughnan, M., Nicholls, N. & Tapper, N. J.	2012	Australia
A study of heat related illness preparedness in homeless veterans	Nicolay, M., M. Brown, L., Johns, R. & Ialynytchev, A.	2016	USA
A common methodology for risk assessment and mapping for southeast Europe: An application for heat wave risk in Romania	Papathoma-Koehle, M., Promper, C., Bojariu, R., Cica, R., Sik, A., Perge, K., ... Glade, T.	2016	Romania
Health of the homeless and climate change	Ramin, B. & Svoboda, T.	2009	Canada
The future of emergency medicine public health research	Rhodes, K. V. & Pollock, D. A.	2006	USA
Managing health impacts of heat in southeast Queensland, Australia	Schuch, G., Serrao-Neumann, S. & Choy, D. L.	2014	Australia
Intra-urban societal vulnerability to extreme heat: The role of heat exposure and the built environment, socioeconomics, and neighborhood stability	Uejio, C. K., Wilhelmi, O. V., Golden, J. S., Mills, D. M., Gulino, S. P. & Samenow, J. P.	2011	USA
The importance of social and community factors	Yardley, J., Sigal, R. J. & Kenny, G. P.	2011	Canada
Impacts of heat waves and corresponding measures: A review	Zuo, J., Pullen, S., Palmer, J., Bennetts, H., Chileshe, N. & Ma, T.	2015	Australia