A meta-analysis of social factors predicting household-level heat-related illness in Phoenix, Arizona

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Introduction

The social and environmental characteristics that make residents more vulnerable to heat-related mortality and morbidity have been the subject of extensive study, particularly in the hot, desert city of Phoenix, Arizona. As part of this effort, numerous social surveys have been conducted in the Phoenix area over the past decade (including the Phoenix Area Social Survey (PASS)). Social surveys are highly valuable to the heat vulnerability research community because they are time and resource-intensive to collect yet are the only way to obtain information related to households’ adaptive capacity to heat and experiences with heat that do not necessarily result in formal medical care or mortality. Unfortunately, the findings from these surveys are often not published and the administration of the surveys in Phoenix has been fairly disparate.

Thus, to synthesize the valuable knowledge contained in these surveys, we conducted a meta-analysis of the various risk factors predicting heat-related illness using eight heat-oriented social surveys conducted in Phoenix over the past decade to address how survey measures of heat vulnerability are related to incidence of heat-related illness.

Methods

Heat surveys in the Greater Phoenix Area (2010-2020)

Seven surveys (right) were included in the meta-analysis. Each survey asked residents’ experience with heat-related illness.

Selection of survey measures

Sixteen survey measures (Figure 1) related to heat vulnerability occurred in at least three of the surveys, and so were included in the meta-analysis.

Using meta-analysis to synthesize survey responses in relation to heat-related illness (HRI)

Calculate effect sizes as odds ratios, controlled for household size where appropriate. Synthesize effect sizes → “summary effect”

In a random-effects model, individual studies are weighted to minimize both between study variance and between study variance

Can quantify heterogeneity of effect sizes between studies:

\[ T^2 = \text{estimated between studies variance} \]

\[ I^2 = \text{proportion of observed variance that reflects real differences in effect size} \]

Used a random-effects meta-analysis model with restricted maximum-likelihood (REML) to estimate \( T^2 \)

Results

Household surveys in the Greater Phoenix Area (2010–2020)

Selection of survey measures

Survey Administered by N year

PASS 2011 Central Arizona-Phoenix Long-Term Ecological Research (CAP LTER) 744 2011

CAPSERS Maricopa County Department of Public Health 338 2013

3HEAT ASU, Georgia Tech, and University of Michigan researchers 163 2016

PASS 2017 Central Arizona-Phoenix Long-Term Ecological Research (CAP LTER) 487 2017

HOA-AR ASU Urban Climate Research Center 203 2017

Socio-demographics

Schmidt Futures-ASU Knowledge Exchange for Resilience via PASI 45 2019

Schmidt Futures project

Tempe City of Tempe 193 2020

Survey Measures (Hypothetical relationship with vulnerability)

1. Low household income (+)
2. Struggle to afford essentials (+)
3. Have enough heat to eat (+)
4. Ethic/racial minority (Hispanic (+)
5. Drive alone (+)
6. Low educational attainment (+)
7. Gender (Female (+)
8. Live alone (+)
9. Poor health status (+)
10. Elderly (+)
11. Central AC (+)
12. Have Window AC to cool (+)
13. Lack air conditioning (+)
14. Feel hot in home (+)
15. Work outdoors (+)
16. Left home because it was too hot (+)
17. Experienced heat-related illness (+)

Key takeaways

- Residents that are too hot in their home are 2x more likely to experience heat illness
- Residents that work outdoors are 2x more likely to experience heat illness
- High heterogeneity of variance for whether residents left their home because it was too hot

Socio isolation and health status

Survey Measures (Hypothetical relationship with health status)

1. Low household income (+)
2. Struggle to afford essentials (+)
3. Have enough heat to eat (+)
4. Ethic/racial minority (Hispanic (+)
5. Drive alone (+)
6. Low educational attainment (+)
7. Gender (Female (+)
8. Live alone (+)
9. Poor health status (+)
10. Elderly (+)
11. Central AC (+)
12. Have Window AC to cool (+)
13. Lack air conditioning (+)
14. Feel hot in home (+)
15. Work outdoors (+)
16. Left home because it was too hot (+)

Key takeaways

- Residents that are too hot in their home are 2x more likely to experience heat illness
- Hispanic people are 1.5x more likely to experience heat illness (due to systemic social inequalities)

Discussion

- Measures of financial wellness other than income may be better indicators of heat vulnerability. Cost restrictions on AC use, not being able to afford essentials, and not having enough food to eat all have a larger effect size on heat illness than household income.
- The ability to modify the indoor thermal environment without restriction protects residents from heat illness; having a central AC unit, being able to use AC without restriction, and home ownership (potentially indicates ability to modify home weatherization) all have a protective effect.
- Living alone, elderly, and health status did not align with the general expectations of heat vulnerability and will require further investigation.

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