Heat-Energy-Vulnerability Nexus: An Empirically Based Thermal Precarity for Urban Residential Households

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Background/Objectives. As climate change progresses, urban areas across the United States are experiencing an increase in the frequency and duration of extreme heat events. Recent history has shown that cities are not often prepared to respond to such events, and heat waves continue to kill more people in the US than any other natural disaster (NOAA, 2022). Emergency heat response protocols are typically based on outdoor temperatures, though heat-related deaths commonly occur inside homes (Klinenberg, 2002; Multnomah County, 2022) where temperatures do not always mirror outdoor conditions. Additionally, we know from prior study (Voelkel et al., 2016) that heat is not evenly distributed across our region, and city- or countywide temperature thresholds for action may delay relief to localized hot spots with temperatures well above average. Heat waves can be devastating to anyone, but exposure and harm are disproportionately concentrated among sensitive populations (young children and the elderly, those with pre-existing health conditions) and those with limited coping capacity (low-income or isolated residents and those in underserved communities, often comprising non-white populations) (Global Heat Health Information Network, 2022; Gronlund, 2014; Voelkel et al., 2018). Local governments are deploying heat pumps, air conditioning systems, and other forms of mechanical cooling to reduce the mortality from extreme heat events, yet lower-income households face greater thermal precarity as a result of degraded or poorly designed urban residential infrastructure.

Approach/Activities. To assess the factors that mediate greater exposure to extreme indoor temperatures, we draw on a unique energy use dataset for four counties in the Portland Metropolitan region (USA), and examine the relationship between sociodemographics, residential infrastructure designs, and a high resolution, spatially-explicit description of outdoor air temperatures. Thermal precarity is a novel concept that builds on a well-established approach used in public health called the ‘safety net’, though more specifically describes the production of precarity during extreme weather events, in our case, extreme heat. The notion that some populations are more exposed to extreme temperatures, thus making them more vulnerable to illness or death, allows for us to draw on empirical measurements of indoor temperatures during the Heat Dome event (June 2021), which killed over 100 people in the study area. Using spatial and statistical analysis we examine differences between indoor and outdoor temperatures, moderating factors that help to explain those differences, and the extent to which energy use has helped to avert empirically-derived thresholds of thermal precarity.

Results/Lessons Learned. Our results indicate that the average energy burden of the low-income households was much higher than higher-income households. While not entirely novel, our findings go further to identify specific sociodemographic factors play a more important role than others in producing thermal precarity within the study region. More specifically, neighborhoods that were 10ºF hotter, had homes that were greater than 30 years old, and contained over 60% of homes below the median household income were more likely to face thermal precarity. Those residents were less likely to turn on available air conditioning or other cooling devices until temperatures reached 95ºF, as opposed to high income and newer homes that engaged with mechanical cooling when temperatures were only 80ºF. Our findings go further to describe a heat-energy-vulnerability nexus that emerges when temperatures reach different thresholds across varying sociodemographics. These findings, we believe are the first to situate increasing temperatures within a framework of energy and vulnerability such that interventions will require different approaches depending on specific constellation of factors that produce thermal precarity.