Assessing and mapping determinants of vulnerability to heat waves in San Francisco

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Background: The human health impacts of extreme heat events are substantial and of increasing concern in the face of climate change, which is predicted to increase frequency of extreme heat events. These health impacts affect the most disadvantaged and vulnerable members of our society, contributing to the climate gap. In San Francisco, potential heat-related health impacts are of interest due to the region's lack of technological and physiological adaptation. Assessing the vulnerability of San Francisco residents to future heat waves can inform public health preparedness and response.

Objective: To assess the relative magnitude and geographical location of potential vulnerability to heat waves within the City of San Francisco, we created and mapped several indexes that combined physical, demographic, and built environment characteristics shown to increase risk of heat-related morbidity and mortality.

Methods: Twenty one variables shown to increase risk were collected for the City at the census block group level. These variables include certain pre-existing chronic health conditions, poverty, social isolation, air conditioning prevalence, high air pollution levels, presence of green space, and more. The variables were defined so that an increase in value would correspond with an increase in vulnerability. A vulnerability index based on z-scores was created by summing the z-score values for the variables for each of the City's 574 census block groups. A vulnerability index based on principle components analysis (PCA) was also created by assigning factor scores to each block group and summing the values.

Results: The varimax-rotated PCA resulted in the retention of 6 factors that explained 68.82% of the cumulative variability. Based on how each variable correlated with each factor, these factors were identified to be: socioeconomic vulnerability, social isolation, air quality, urban density, no vegetation, and elderly population. Both index-creation methods created similar patterns of relative vulnerability, with the following neighborhoods identified as highly vulnerable: Chintown, Downtown Civic Center, Bayview, and Mission.

Conclusion: This methodology identifies both the main factors that contribute to relative heat-wave vulnerability and the geographical location of the most vulnerable, allowing planning efforts to be tailored both geographically and by cause. These methodologies differ slightly in results and remain sensitive to practitioner decisions; validation against heat-related health outcome data can advance understanding of model sensitivity and appropriateness.