Clarifying the Connections Between Green Space, Urban Climate, and Heat-Related Mortality

See also Dang et al., p. S137.

Strategies to reduce urban heat via infrastructure and landscape modifications are commonly expected to lower heat-related health risks. In theory, manipulating the atmospheric variables that can raise core body temperature—air temperature, moisture content, wind speed, and radiation (long wave and short wave)—can reduce heat exposure and thus the risk of heat-related death. In this issue of *AJPH*, the article by Dang et al. (p. S137), sheds light on the potential health benefits that could be realized from one particular heat mitigation strategy—the addition of green space to the urban landscape.

The article was largely grounded on the integration of high-resolution meteorological simulations from the Weather Research and Forecasting Model with mortality records for Ho Chi Minh City, Vietnam. The authors modeled the exposure–response relationship at the district level, which enabled them to isolate the potential contributions of intraurban temperature variability to heat-related mortality. The results suggest an effect of urban heat on mortality that is independent from background meteorological conditions. Subsequently, the authors used correlation analysis to estimate how the fraction of mortality attributable to heat would change if the green space fraction was increased at the district level. They concluded that increasing the density of green space could lead to a reduction in the number of heat-attributable deaths in the city.

KEY ASSUMPTIONS

Ideally, the design of quantitative studies such as this one would be on the basis of a thorough understanding of the full causal pathway that links urban heat exposure and health outcomes at the scale of individuals. Clarifying our knowledge of the precise manner in which interaction with urban green space reduces personal heat exposure and thus reduces risk of an adverse health event is an important objective for environmental health researchers. In the absence of this fine-scale understanding, the authors ask the readers to assume that (1) the addition of green space would reduce daily mean air temperature, and (2) the subsequent air temperature reductions would be realized for the specific weather conditions, times of day, and locations where dangerous personal heat exposure occurs.

The first of these assumptions could have been investigated with the same modeling tool the authors used to estimate district-level baseline meteorological conditions, facilitating the calculation of a physically consistent impact of green space deployment throughout the diurnal cycle. Modeling and observational studies indicate that the impact of urban green spaces on air temperatures can be both spatially and temporally variable; localized meteorological conditions and circulation patterns, along with the specific arrangement and type of green features, can influence their effectiveness.[1]

The second assumption concerns the time activity patterns of urban dwellers, which are more difficult to assess. The authors acknowledge the potential for exposure misclassification in their derivation of the exposure–response relationship for the study population. As with all dynamic and statistical approaches, misclassification in the estimated exposure reduction may be an additional concern: if the personal heat exposure that is causing heat-attributable mortality is occurring at places or times that are different from those where the impacts of urban green space addition would be realized, it would be unlikely that the incorporation of green space would substantially reduce heat-related deaths. Emerging research integrating wearable sensors and computational modeling to understand the nature of personal heat exposure in cities should make it more possible to evaluate whether and how specific heat mitigation activities will affect exposure circumstances of concern.[2]

GREEN SPACE AND THERMAL ENVIRONMENT

Careful attention is needed in choosing meteorological parameters when linking heat mitigation strategies to human health. Impact estimates can be highly sensitive to parameter choice, even between highly correlated variables like daily maximum, mean, and minimum temperature.[3] The urban heat island effect, the focus of this article, is

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predominantly a nighttime phenomenon. Comparisons of paired urban and rural temperatures consistently demonstrate that the main impact of urban structures is the reduction of nighttime cooling. Thus, minimum temperatures are better indicators of the urban heat island than are daily mean or maximum temperatures. Similar complexities are introduced when considering the effects of the addition of green space. In the case of trees in particular, the impacts on air temperature can vary diurnally as a function of many factors, including canopy density and localized circulation patterns.[4] Trees can reduce near-surface daytime shortwave radiation while simultaneously increasing atmospheric humidity, highlighting the utility of metrics that are more thermally comprehensive than air temperature.[5,6] Future studies incorporating atmospheric humidity might focus on variables more closely related to evaporative potential, including wet bulb temperature. The use of relative humidity, which is confounded by air temperature and is less physiologically meaningful, should be avoided in studies concerning heat stress.[7]

IMPLEMENTATION GUIDANCE

This article helps draw attention to two important issues at the intersection of urban environments and human health. First, the authors document a sizable impact of the urban heat island on heat-related mortality. Most research to date projecting future heat-related mortality has focused on global-scale climate change, but the impacts of urban-scale forcing alone can be substantial.[3] Second, the authors seek to provide useful information for local policymakers and generate a return on investment-style metrics to do so, and we applaud the authors' motivation and creativity along these lines. However, this research serves as a reminder that there is more work to do by the biometeorological and environmental health communities at large in conjunction with the climate modeling community to provide information that is definitive, precise, and actionable.

Answers to several questions are necessary to derive clear guidance from the study findings, including (1) What are the spatial and temporal scales and domains at which the results are valid? (2) Would the arrangement and type of the urban green space (e.g., trees vs grass) influence the number of lives saved? (3) Is deployment of urban green space at a density of one square kilometer per 1000 people reasonable in a city with an average population density of 2660 people per square kilometer? and (4) If more or less green space is deployed than the proposed ratio, how would the number of potentially avoided deaths change? Finally, an improved understanding of the circumstances of the individuals who suffer from heat, such as the nature of their employment and their access to air conditioning, would help advance this type of research. Detailed circumstantial information will facilitate strategic deployment of urban green infrastructure, as one in a portfolio of strategies, to reduce underlying vulnerability.

A more thorough consideration of exposure circumstances, environmental variables, and the physical dynamics of the urban climate may be useful for all researchers striving to communicate the potential health impacts of urban heat mitigation through the provision of green space. AJPH

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