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Editorial

Towards the Integrated Study of Urban Climate, Air Pollution, and Public Health

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Globally, cities are growing at an unprecedented pace, putting pressure on space, existing infrastructure, and resources. At the same time, the function and form of cities is rapidly evolving as planners and decision makers race to meet the changing needs of the population within the context of unequal resource allocation and variable risks imposed by environmental threats such as climate change and air pollution [1,2]. Designing and planning sustainable cities, resilient to environmental and population change, which also promote human wellbeing and healthy lifestyles, is therefore one of the greatest challenges of the 21st Century. This Special Issue, edited by the Healthy-Polis International Consortium for Urban Environmental Health and Sustainability (www.healthy-polis.org), aims to explore these interactions between urban climate, air pollution, and public health in cities around the world.

Air pollution remains one of the biggest threats to human health and wellbeing in cities. Outdoor air pollution causes approximately 4.2 million premature deaths annually worldwide [3]. Pressure is greatest in urban areas of rapidly developing countries such as China and India [4]. The indirect health consequences of air pollution are maybe just as costly from an economic, social, and health perspective, including loss of productivity and reduced educational performance [5,6]. Given the dynamic physical and social conditions of urban environments, it is perhaps not surprising that the complex interactions between urban climate, air pollution, and public health remain poorly understood and difficult to predict. Multiple feedback processes, driven by the unique and location-specific characteristics of urban surfaces and the ways we use urban land, further complicate the links between climate, air pollution, and public health. Urban structures, materials, vegetation, and traffic modify climatic conditions, creating strong spatial gradients of air pollution and heat, which may exacerbate health risks and social inequalities in temporally and spatially disparate ways [7]. Planned or unplanned changes in the built environment and demographics (which determine mobility, vulnerability, and occupation) can change patterns of exposure to environmental hazards such as air pollution and temperature extremes, and in some cases intensify health effects. The interaction between the outdoor and indoor environment can also influence exposure patterns to both climate and air pollution variables and thus affect health impacts [8].

Although the health impacts of air pollution on urban populations are nuanced by socio-economic factors [9], climate, and pollution severity, the consequences can be observed in cities around the world. In this special issue, the effects of air pollution on urban populations are explored in a range of locations including the heavily polluted city of Kolkata (India) [10], where respiratory illnesses now exceed waterborne illness by a factor of five. Further examples are provided by Xu et al. [11] and Guariso and Malvestiti [12] who examine the social, economic, and health consequences of pollution in the comparatively moderately polluted urban areas of Hong Kong (China) and Milan (Italy), respectively. However, the impacts of pollution are significant even where much lower air pollution levels are

reported, in Kuopio (Finland) [13] and Auckland (New Zealand) where Dirks et al. [14] demonstrate the relation between daily mortality and local traffic-related air pollutants.

Air pollution is not only toxic to the human body but also interacts with climate. Short lived climate pollutants (SLCP), such as black carbon and ozone, can exacerbate climate change, altering the frequency, duration, and location of heatwaves and cold spells, storm intensity, precipitation patterns, and, possibly, ultra-violet radiation exposure, indirectly threatening urban lives and livelihoods [15]. On the other hand, a warmer climate can have an impact on biogenic volatile organic compound emissions, the rate of atmospheric chemical reactions, and the depth of the atmospheric boundary layer, which all affect surface pollutant concentrations [16]. Using a meta-analysis of 246 cities and 18 different climate model scenarios, Milner et al. [17] illustrate the high probability of climate change that presents significant challenges to the future resilience of urban areas and the protection of public health, as urban populations are projected to be exposed to higher temperatures than are currently experienced.

Several papers in the special issue provide examples that demonstrate the importance of tackling urban climate, air pollution, and public health issues together, particularly in cities where multiple co-benefits of targeted strategies can be realised and the dangers of attempting to mitigate environmental pollution using single parameter optimization can be avoided [18]. Naik et al. [19] show how effective a multi-parameter health assessment methodology is for determining the net impact of low emission zones in cities. They demonstrate significant health and environmental co-benefits from the implementation of such measures for a city in the UK. In contrast, Asikainen et al. [13] demonstrate that policies that are intended to reduce greenhouse gas (GHG) emissions may have unintended impacts on local air quality. They show that mitigation by the transition to alternative fuels and energy sources, energy conservation, and land use modification may have significantly different outcomes for human health and wellbeing. They also highlight the importance of assessing local scale impacts, suggesting that whilst the increased use of domestic wood burners would likely result in negative impacts on health, there are significant economic and health gains to be made by promoting strategies that reduce traffic-related emissions by promoting active transport modes such as cycling and walking. Milner et al. [20] further demonstrate the need for careful consideration of the links between climate, air pollution, and health. They argue that whilst reductions in GHG emissions through improvements in residential energy efficiency achieved by increased insulation may have appreciable near-term net benefits to health due to better indoor thermal regulation and reduced exposure to outdoor pollutants, these may be offset by increased exposure to indoor sources of pollution due to reduced ventilation.

Attempts to effectively manage urban air pollution require careful resolution of the challenges, tensions, and conflicts between different social, economic, and environmental priorities at different scales. Using a combined approach, the benefits to public health and the environment associated with increased use of cycling are explored by Guariso and Malvestiti [12]. They examine the trade-offs between increased physical exercise and reduced emissions of pollutants (especially GHG) versus potentially increased exposure of commuters to air pollution associated with switching from motor vehicles to bicycles. Their modelling shows that when just taking into consideration these parameters, the overall balance for public health in Milan, Italy, was always in favour of cycling. Guariso and Malvestiti [12] further demonstrate that when factors such as road space and economic factors were taken into consideration, the balance in favour of cycling was even stronger. Again, this paper reveals that tackling climate, air pollution, and public health (through promotion of increased physical activity) together can result in significant overall gains.

This special issue also suggests that one of the keys to managing air pollution, climate change, and public health concerns effectively in urban areas is to improve our understanding of the ways in which urban land use affects human health outcomes. Xu et al. [11] address the challenges associated with quantifying the effect of green space on air pollution exposure, climate, and health. In the densely populated sub-tropical city of Hong Kong, China, they show that greater provision of green space has the potential to reduce mortality due to beneficial effects on exercise and stress, improved air quality,

and reduced urban heat islands. They note the socio-economic differences in health outcomes, with the greatest benefits realised by males and those living in areas with below-average median household income. The importance of understanding the impact of air pollution on health in the context of total personal exposure and, particularly, the quality of the indoor environment is also highlighted in a methodological analysis by Milner et al. [20].

Effective urban planning therefore requires a clear understanding of the interactions between the social, economic, and physical process operating in cities and how these play out in the ways urban land is used in space and time. As cities and populations become increasingly 'digital', the amount of data available to describe human interactions with different urban microenvironments has increased exponentially, and the potential for new insights is unprecedented. However, a better description of urban environments alone has yet to deliver an improved understanding of processes that lead to better urban planning and development. Rather, we need innovative ways to explore and analyse this explosion of data ("Big Data") if we are to see any real changes in the ways we plan, manage, and mitigate air pollution, climate change, and their impacts on cities [21]. Mahmood et al. [22] show how large data sets from routinely collected sources, in this case ambulance call outs, can be combined with climate data to provide an improved understanding of the impact of climate extremes on ambulance response times in London, UK. Their results demonstrate that not only can such near real time data provide pathways for improved urban management, but new understandings also offer the potential for improved health service provision.

As we adapt to a warmer climate, we need to ensure that our urban atmospheres are treated as a resource and sustainably managed. The papers in this issue enrich the current interdisciplinary, multi-parameter evidence base for decision making in urban planning and design, environmental protection, and public health. Effective urban growth and regeneration planning, which pays attention to the creation of more sustainable transportation options and building climate control measures, is required to maintain and improve public health in cities. Efforts need to target reduced emissions through the promotion of active modes of transport and home heating/cooling measures [13,20]. The provision of less polluted [19] and less noisy outdoor spaces, which promote exercise and wellbeing, will ultimately reduce the burden of non-communicable diseases [11,12].

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