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Review article

Defining pathways to healthy sustainable urban development☆,☆☆

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ABSTRACT

Goals and pathways to achieve sustainable urban development have multiple interlinkages with human health and wellbeing. However, these interlinkages have not been examined in depth in recent discussions on urban sustainability and global urban science. This paper fills that gap by elaborating in detail the multiple links between urban sustainability and human health and by mapping research gaps at the interface of health and urban sustainability sciences. As researchers from a broad range of disciplines, we aimed to: 1) define the process of urbanization, highlighting distinctions from related concepts to support improved conceptual rigour in health research; 2) review the evidence linking health with urbanization, urbanicity, and cities and identify cross-cutting issues; and 3) highlight new research approaches needed to study complex urban systems and their links with health. This novel, comprehensive knowledge synthesis addresses issue of interest across multiple disciplines. Our review of concepts of urban development should be of particular value to researchers and

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practitioners in the health sciences, while our review of the links between urban environments and health should be of particular interest to those outside of public health. We identify specific actions to promote health through sustainable urban development that leaves no one behind, including: integrated planning; evidence-informed policy-making; and monitoring the implementation of policies. We also highlight the critical role of effective governance and equity-driven planning in progress towards sustainable, healthy, and just urban development.

1. Introduction

Urbanization is one of the dominant demographic trends of the 21st Century. In 2018, 55% of the population resided in urban areas; this is projected to be 68% by 2050, with this growth overwhelmingly concentrated in Asia and Africa (United Nations Department of Economic and Social Affairs Population Division, 2018a). Over a century, society has transformed from predominantly rural to urban settlements. But how well do we understand the impacts of urbanization on human physical and mental health? How can urbanization be shaped to mitigate and adapt to climate change while protecting human health and reducing social and health inequalities? Which research approaches are best suited to understanding the links between health and large-scale changes like urbanization?

While the health and wellbeing of current and future generations is an explicit goal of sustainable urban development (Elmqvist et al., 2019), previous discussions have connected urban sustainability and health in relatively general terms (Acuto et al., 2018; Elmqvist et al., 2019). There is a critical need to further elaborate the multiple dependencies between urban sustainability and human health to breakdown silos between the urban sustainability and health sciences and map methods and knowledge gaps at the interface of these fields.

We brought together researchers from a wide range of disciplines with the objective to identify pathways to optimize sustainable urban development for human health (i.e. healthy sustainable urban development). Specifically, we aimed to: 1) define the process of urbanization, highlight distinctions from related concepts (e.g., urbanicity, cities), and identify its drivers and metrics relevant for health; 2) review the evidence linking urbanization, urbanicity, cities and health and identify cross-cutting issues; and 3) consider new research approaches needed to study complex urban systems and their relationships with health. Section 1 should be of particular value for researchers in the health sciences. While many of the concepts related to urban development in Section 1 are familiar within urban planning and related disciplines, they have not been taken up widely within the health sciences, potentially limiting the wider impact of this literature. Section 2 should be of interest primarily to researchers focusing on urban sustainability from disciplines outside of public health. The process to arrive at interdisciplinary knowledge synthesis involved discipline-specific contributions, followed by focused debates, and small group discussion to identify opportunities for promoting health through urban development in specific sectors or from the perspective of cross-cutting themes, including: housing, land use, mobility, equity, and social stress.

2. Urban development concepts relevant to health

Urbanization, urbanicity, and cities are often used interchangeably in the public health literature. These concepts, while related and each relevant for health, are distinct and require different research approaches. There is a clear need for more conceptual rigor in the literature to standardize terms in order to better elucidate how this set of concepts influence physical and mental health (Table 1). Interdisciplinary teams including health researchers, urban planners, demographers, economists, computer scientists, and experts in geospatial analysis, are best placed to undertake research focused on urban systems and health, and to develop more refined measures and research approaches to advance understanding and identify relevant interventions.

2.1. Urbanization

Most of the literature conceptualizes urbanization as a process of change over time in size, density, and heterogeneity of human settlements (Cyril et al., 2013). Urbanization entails a shift in populations that are dispersed across small rural settlements with agriculture as the dominant economic activity towards concentrated populations in larger, dense urban settlements characterised by industrial and service activities (National Research Council, 2003; United Nations Department of Economic and Social Affairs Population Division, 2015). Multiple factors can act as drivers of urbanization including demographics, economic development, and policy. Urban population growth can result from: an excess of births over deaths (natural increase); rural-to-urban migration; and the reclassification of rural localities as urban. Push factors such as poverty, social disruptions caused by conflict, land losses and captures, and extreme weather events, and unemployment (possibly amplified by climate change), are important drivers for people to leave rural areas or countries. Simultaneously, pull factors such as greater economic opportunities (e.g., higher wages), access to services, and modern facilities attract people to urban areas. The spatial distribution of the population is also explicitly shaped by migration policies, including strategies to

Table 1
Typology of urban development and relevance for health research.

Urban development type	Description	Relevance for health research
Urbanization	Change over time in size, density, heterogeneity of settlements	Changes over time in health status of populations or individuals due to exposures downstream of urbanization (e.g., health behaviors, land use, air pollution)
Urbanicity		
	Urban-rural dichotomy based on single factor	Relevant for public health planning, but more limited for studies of etiology due to poorly defined categories and lack of comparability of categories across locations
	Muti-component scale based on multiple dimensions of urbanicity	More appropriate than dichotomy for etiological studies, but may lack comparability of across locations.
Cities		
	Administrative boundaries	Well-suited for research on influence of policy, governance decisions on health
	Metropolitan areas	Relevant for health research on exposures directly influenced by city but that do not respect administrative boundaries (e.g., water and air pollution)
	Physically defined	Well-suited for research on physical exposures (e.g., Urban Heat Island)
	Functionally dependent system including cities and the resources on which they depend	Relevant for studies of how urban systems drive global environmental changes and their influence on health

reduce rural to urban migration (United Nations Department of Economic and Social Affairs Population Division, 2016).

2.2. Urbanicity

Rather than a process, urbanicity is static: the influence of living in an urban area at a given time (Cyril et al., 2013). Urbanicity is a latent variable that cannot be directly measured. Given the wide heterogeneity in situations globally, there are currently no uniform criteria adopted by all countries to distinguish urban from rural areas. The United Nations' World Urbanization Prospects, a widely cited source, bases its estimates and projections on data from national sources, which reflect the varying definitions and criteria established by national authorities for the percentage urban (United Nations Department of Economic and Social Affairs Population Division, 2018b). These criteria vary widely across countries; for example, the minimum number of inhabitants used to define whether a locality is urban is 200 in Denmark and 20,000 in Nigeria (United Nations Department of Economic and Social Affairs Population Division, 2019a).

While administrative units are still the legal basis for policy- and decision-making, alternative units of analysis are needed to more fully understand interrelationships relevant for health. Lack of established comparable units poses a challenge for researchers investigating how the urban environment shapes health. This is reflected in the wide heterogeneity in definitions of even a simple urban-rural dichotomy, or its extension (e.g., rural, *peri*-urban, suburban, urban), found in the health literature. As an illustration, we summarize different definitions used in the literature in relation to cardio-metabolic risk (Table 2). The urban-rural dichotomy has important disadvantages for accurate representation of urbanicity, for example, 'rural' is not comparable across low and high-income countries and masks differences in important features and their interactions (den Braver et al., 2018; Galea and Vlahov, 2005). Multicomponent metrics have been developed including dimensions of urbanicity related to population size, density, and access to goods and services. Such metrics capture a continuum of urbanicity, providing more granularity on transition areas, and have been shown to outperform the urban-rural dichotomy based on a single factor for predicting population health status (Dahly and Adair, 2007; Jones-Smith and Popkin, 2010). Nonetheless, multicomponent urbanicity scales often lack generalizability from one location to another (Allender et al., 2008; Cyril et al., 2013; Jiamjarasrangsi et al., 2016) and require extensive data collection (Cyril et al., 2013). Integrating new data sources (e.g., remote sensing, street view, and mobile phone data) and machine learning data processing could potentially reduce the burden of data collection and large-scale analysis, and expand the breadth or features included in urbanicity metrics.

2.3. Cities

Cities are a key target for health and sustainability research and intervention given their potential to drive solutions as well as concentrate health hazards. However, most health research focusing on cities has not been clear what is meant by "city". Cities are often defined based on administrative boundaries that do not necessarily coincide with the extent of urbanized territory (Fig. 1). Alternative concepts have been used to improve comparability of measurements of city populations across countries and over time. Urban agglomerations refer to the population contained within contours of a contiguous territory with urban levels of residential density. Metropolitan areas extend this by also including surrounding areas with lower settlement density that are under the direct influence of the city through socio-economic and other links (United Nations Department of Economic and Social Affairs Population Division, 2018b). Other definitions attempt to capture these functional dependencies, for example Functional Urban Areas, use commuting data to define the commuting zone surrounding a city in a comparable way that can be used across countries (Dijkstra et al., 2019).

Table 2
Definitions of urbanicity used to evaluate the relationship with cardio-metabolic health.

Author, Year	Country	Urbanicity definition	Components of definition
Urban-rural dichotomy			
van der Sande et al., 2000	Gambia	Geospatial contrast	Urban: Capital city Rural: rural community, distant 150 km inland
Lindroth et al., 2014	Sweden	Response to the question "Where do you live"	Urban or city: larger community (>15,0000 inhabitants) Town: community >1000 inhabitants Rural: community <1000 inhabitants
Supiyev et al., 2016	Kazakhstan	Geospatial contrast	Urban: state capital; population 858,302; population density 1188 persons/km^2 Rural: distant village; population 6,000; population density 7.7 persons/km^2
Chiwanga et al., 2016	Tanzania and Uganda	Geospatial contrast and population density	Urban Tanzania: primary school teachers from a major commercial city (Dar es-Salaam) Peri-urban Uganda: about 15 km from the capital, population of two million and 59% of population in within 5 km radius of a health unit area Rural Uganda: population of 250,000, 70% is within a walkable distance to a healthy facility
O'Neal et al., 2018	USA	Core-based statistical area (geographic area)	Urban: metropolitan area (areas that contain at least 1 urbanized area of 50,000 or more population) Rural: micropolitan area (at least 1 urban cluster that has a population of 10,000–50,000) or noncore (not metropolitan or micropolitan)
Continuum			
Dahly and Adair, 2007	Philippines	Multicomponent scale incorporating 7 domains	Population size; Population density; Communications; Transportation; Educational facilities; Health services and Markets
Allender et al., 2010	India	Modified-Multicomponent scale incorporating 7 domains	Replication of original scale: Population size; Population density; Educational facilities Adapted to India: Communications; Transportation; Health services and Markets
Jones-Smith and Popkin, 2010	China	Multicomponent scale incorporating 12 domains	Population density; Economic activity; Traditional markets; Modern markets; Transportation infrastructure;

(continued on next page)

Table 2 (*continued*)

Author, Year	Country	Urbanicity definition	Components of definition
			Sanitation; Communications; Housing; Education; Diversity; Health infrastructure and Social services
Attard et al., 2015	China	Multicomponent scale incorporating 12 domains	Population density; Economic activity; Traditional markets; Modern markets; Transportation infrastructure; Sanitation; Communications; Housing; Education; Diversity; Health infrastructure and Social services
Novak et al., 2012	Multicountry (Ethiopia, India and Peru)	Multidimensional scale incorporating 7 domains	Population Size; Economic Activity; Built Environment; Communication; Education; Diversity and Health Services.

Alternative definitions of cities have focused on how cities are embedded in space (e.g., connected clusters of populated settlements (Rozenfeld et al., 2008) or urban land cover (Fluschnik et al., 2016)), which may be more relevant for health research focused on physical phenomena (e.g., Urban Heat Island (Zhou et al., 2013)). Even the concept of metropolitan area fails to capture the multi-scale, multi-dimensional teleconnections between cities and the resources (e.g., energy, water, food) on which they depend. For some health-related research questions, it may be necessary to use alternative definitions of cities that more fully capture their embedded resources and wider impacts. For example, cities cover around 1% of global land surface (Esch et al., 2017), but consume the majority of Earth's material resources (Pincetl, 2017; United Nations Environment Program, 2016), and are estimated to produce up to 50% of total greenhouse gas emissions (Marcotullio et al., 2013). Notably, most estimates of emissions of greenhouse pollutants focus only on within-city activities, without fully accounting for indirect, embodied emissions in the goods consumed within the city but produced elsewhere. Better accounting of the scale and nature of resource flows is needed to more fully understand how cities drive global environmental changes that have implications for health (Pincetl, 2017).

3. Links between urbanization, urbanicity, cities and health

Quality and access to health services is one important mechanism by which urbanization and urbanicity shape health (Matthews et al., 2010). However, a range of other factors play a role. To highlight the relevance of pathways by which urban environments affect physical and mental health other than through health services, this section provides a concise review of the state-of-the science regarding specific pathways through which urban environments shape physical and mental health.

3.1. Demography and implications for health

Virtually everywhere, including within urban areas, the share of older persons (aged 60 or more years) is increasing as an outcome of increasing longevity and declining birth rates. The number of older people globally is projected to grow from 1.0 billion in 2019 to 1.4 billion in 2030, and to 2.1 billion in 2050, with 80% living in low- and middle-income countries (LMICs) (United Nations Department of Economic and Social Affairs Population Division, 2019b; World Health Organization, 2018). Currently, nearly 60% of older persons live in towns and cities (World Health Organization, 2018). Urban areas have an important role in delivering better health outcomes for older adults by helping them meet their basic needs, learn, make decisions, maintain mobility, build and maintain relationships, and contribute to society. Age-friendly urban environments are free from physical and social barriers; supported by policies, systems, services, products, and technologies that promote health, build and maintain physical and mental capacity across the life course; enabling people, even when experiencing capacity loss, to continue to do the things they value (World Health Organization, 2018). As populations in urban areas grow older, they influence urban development through changes in densities, commuting patterns, and land and housing markets. This reflects changes in demand due to older persons increased mobility challenges, preferences for different modes of transport, increased propensity to live around transit nodes (since many older persons are no longer able to drive), and preferences for certain types of housing (e.g., free of stairs and other barriers). Urban areas with ageing populations require flexible designs in planning and infrastructure, and updating of plans to ensure that they are suitable to current demographics (OECD, 2015). Universal design to ensure that infrastructure and services, including housing, are accessible to all persons, including those with limited mobility or visual, hearing or other impairments, will play an important role in maintaining their inclusion in society and promoting health. While ageing populations are a dominant demographic trend, design and management of urban areas should accommodate the needs of all users, regardless of age and abilities.

Household size and composition vary with urbanicity, with potential implications for physical and mental health (Grinde and Tambs, 2016). For example, multi-country data from the past several decades indicates that average number of members in a household is smaller in urban compared to rural areas, with a much higher percentage of single member households in urban areas (United Nations Department of Economic and Social Affairs Population Division, 2018c). Evidence suggests that living alone can be linked with poorer mental health (Tamminen et al., 2019) and unhealthy diets (Conklin et al., 2014; Hanna and Collins, 2015). Cities have long been recognized as providing an additional sense of freedom and opportunities to escape from a fixed, inherited position in the economic and social hierarchy (Sennett, 2018). However, taken to its extreme, this freedom for the individual in the city, may lead to social isolation with important implications for health.

3.2. Climate change and health

Urban areas are increasingly the focus of strategic action on climate change. A large part of urban areas of LMICs have yet to be built. How these areas are constructed over the coming decade will determine the consumption practices of several billion people through the end of the century: for example, through sources of household energy for cooking, heating, and cooling; travel modes and distances, and sources of energy for transportation. These choices will have important consequences for climate change mitigation and adaptation, with most choices not motivated by climate change alone but rather local development priorities (Khosla and Bhardwaj, 2019).

Many climate change impacts in urban areas will have direct consequences for health. For example, evidence regarding impacts in urban areas summarized in a recent report by the Intergovernmental Panel on Climate Change indicates that even at 1.5 °C warming, twice as many megacities (including Lagos, Nigeria and Shanghai, China) could become heat stressed, exposing more than 350 million additional people to deadly heat by 2050. With 2.0 °C warming, Karachi, Pakistan and Kolkata, India could experience conditions similar to the deadly heatwaves of 2015 on an annual basis in the absence of adaptation. Stabilizing at 1.5 °C rather than 2.0 °C could decrease mortality due to extreme temperatures in European cities, assuming no adaptation and constant vulnerability (Hoegh-Guldberg et al., 2018). Many impacts of

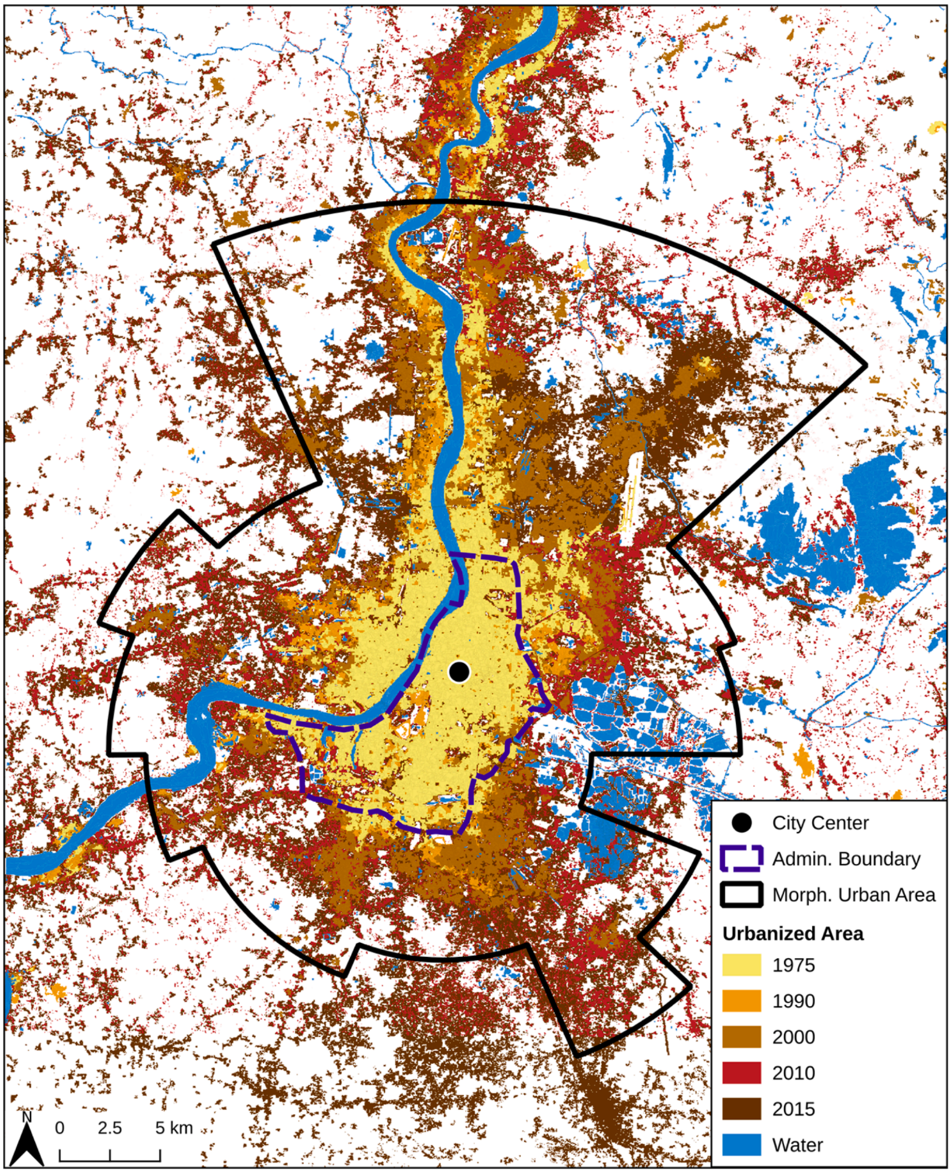

Fig. 1. A significant difference between spatial units for (Kolkata, India). The difference between the administrative unit and a morphological urban area is visualized over the settlement area. In the 1970s, the extent of the built city is still more or less congruent with the administrative unit, the expansive growth of the city's built area has resulted in a multiple spatial extents over time. The morphological unit is based on an approach that allows the boundary between city and countryside to be determined uniformly for any given city (Taubenböck et al., 2019) thus a) making it more suitable to today's built city and b) providing a reasonable spatial baseline for comparative studies.

climate change will have distinct implications for the health of the urban poor. Informal settlements, already particularly vulnerable due to overpopulation, high building density (Klotz et al., 2016), and poor housing quality, are often located on land that is highly exposed to climate-related hazards, including sea-level rise, coastal flooding, riverine flooding, and landslides. Settlements are located on such land because of convenience for accessing livelihood opportunities and potentially lower risk of eviction compared to less hazardous locations (Williams et al., 2019). Climate change projections indicate increases in the frequency and intensity of storm events and floods, the natural hazard most frequently experienced by the urban poor. The impacts on flooding on the urban poor are amplified by the frequent location of informal settlements in floodplains, and insufficient waste and drainage systems. Among other impacts, those related to health include injury and death, population displacement and the spread of infectious diseases (Williams et al., 2019). Similarly, land use and housing policy that permit residential development in fire prone areas, increase the risk of loss of life and property, particularly given climate change (Syphard et al., 2019).

3.3. Food systems, diet and health

Globally, there have been dramatic changes in the nature of food systems, the structure of diet, and patterns of work, physical activity, and sedentary behavior that have been major drivers of obesity and related non-communicable diseases. These changes include the nutrition transition occurring most rapidly in LMICs and in the context of urbanization (Popkin, 1994). The major dietary trends associated with the nutrition transition include increased intake of caloric sweeteners, fats and oils, animal source foods, processed foods, and refined carbohydrates, and reduced intake of fruits, vegetables and legumes. At the same time, and particularly in the context of urbanization, there is a transition away from physically demanding occupations and household chores and toward more sedentary jobs and leisure activities.

Urbanization is associated with dramatic changes in the patterns of land use, demographic structure, occupation types, and aspects of lifestyle and culture associated with the growth of cities (Popkin, 2017). These have important implications for many aspects of food systems and individual diet patterns. With urbanization, there is loss of agricultural land, longer supply chains related to bringing foods to consumers, including processing and packaging of food, and challenges related to food distribution and sales, all of which can affect food costs and quality. On the individual level, changing patterns of time use among urban dwellers increases reliance on packaged foods with longer shelf life, and precooked foods, many of which have lower nutritional quality and higher levels of chemical contamination (Vilarinho et al., 2019). Accompanying urbanization, there are parallel economic development and increases in income, which affect food preferences and access to food with important implications for diet quality and health (Seto and Ramankutty, 2016).

Urbanized communities face numerous challenges in obtaining high quality, affordable food. First, urban dwellers are most often buyers, not producers of food (International Food Policy Research Institute, 2017). They are highly influenced by food prices, and the least expensive foods are often low quality, processed foods with high energy but low nutrient density. Urban dwellers are highly reliant on food value chains and transportation infrastructure. Their time demands for work, particularly for women, create a demand for more convenience and fast food options, which are also more likely to be of high energy, low nutrient density. Moreover, fuel costs for cooking may drive increased intake of precooked foods (International Food Policy Research Institute, 2017). There are special concerns for the urban poor. Food insecurity and malnutrition are highly prevalent in urban slums. Obtaining food requires cash, and extremely poor urban households in many developing countries spend more than 50% of their income on food. The urban poor are often employed in the informal sector, and this leaves them vulnerable to income and food price shocks. At the same time, there can be benefits of urbanization for those with higher incomes. High food variety, and wide availability of high-quality foods at supermarkets can allow for healthy dietary patterns.

The positive and negative effects of urbanization on the food environment, as well as high levels of income disparities within urban settings contribute to a dual burden of under and overnutrition and related diseases among urban populations. The dual burden may occur in individuals, households, or communities (Tzioumis and Adair, 2014). While among urban populations, undernutrition has historically been found among the poorest populations, the burden of obesity is increasingly shifting to poor in LMICs, for example urban slum populations in India (Yadav and Krishnan, 2008). Ultimately, this poses new, serious challenges for health care systems trying to address the dramatically changing health care needs of urban populations.

3.4. Land use and transport policy, travel behaviour, and health

Land use and transport policies determine which activity types and related facilities (e.g., dwellings, schools, shops, industry, medical and other services) are allowed or prohibited at which locations and the feasible transport options to reach those facilities. Land use influences individuals' travel behaviour by affecting the availability and proximity of destinations. This includes planning policies and regulations that prescribe building density (and indirectly population density), the level of mixed land use, connected street network design, the provision of cycling infrastructure, distances of residences to facilities including public transport nodes (stations, stops), and the attractiveness and desirability of areas and different transport modes (Ewing and Cervero, 2010).

Travel behaviour influences the health of travellers and others in their community in several complex ways (van Wee and Ettema, 2016). First, walking and cycling are a form of physical activity which is strongly linked to a number of health benefits for the traveller (Warburton and Bredin, 2017). Second, use of active or public transport reduces the need for private motorized transport, which improves air quality and reduces noise, enhancing the health of others. Third, individuals' exposure to air pollutants during travel depends on trip duration, air pollution concentrations, and inhalation rate, which, depending on the setting and pollutant, can be higher during active travel. However, modelling studies that have considered potential health trade-offs of active travel indicate that the health benefits of physical activity during active travel predominantly exceed risks from increased air pollution exposure (Tainio et al., 2016). Fourth, road traffic injury risk for the traveller and for other road users varies by travel mode (Aldred et al., 2020). Fifth, travel behaviour at multiple scales (e.g., local (Goscé and Johansson, 2018), regional (Strano et al., 2018), and international (Findlater and Bogoch, 2018)) has important implications for transmission of infectious diseases.

The complex relationships between land use, travel behaviour, and health of travellers and others are largely understood conceptually, but very poorly quantitatively, resulting in an important evidence gap. Even with more complete quantitative evidence regarding these relationships, policy makers need to balance the pros and cons of health-related impacts of land use with other factors, such as accessibility, costs borne by travellers, infrastructure costs, environmental impacts, and overall quality of life (van Wee, 2002). In many settings, the bicycle is an attractive solution for short trips, because it involves physical activity, provides relatively inexpensive, flexible access to destinations, and does not have the car-related adverse environmental impacts (Pucher and Buehler, 2012). Bicycle mode share varies considerably between cities, regions and countries, and even within cities (e.g. by gender, ethnicity, socioeconomic factors) and remains low in many urban areas and subpopulations. Factors influencing this share include, amongst others, the quality of cycling infrastructure, attractiveness of routes, hilliness, perceived safety of cycling, and general attitudes towards cycling (Pucher and Buehler, 2012).

3.5. Air pollution, urbanization, and health

Outdoor air pollution is a major global public health issue, responsible for approximately 8% of deaths globally (Cohen et al., 2017). It is associated with a broad range of adverse health effects, including effects in nearly every human organ system (Thurston et al., 2017). Exposure can be highly unequal between and within urban areas around the world (Hajat et al., 2015). An extensive literature characterizes spatial gradients in outdoor air pollution allowing for comparisons of air pollution across urbanicity gradients. However, relatively little literature explores how air pollution changes over time with the urbanization process. This knowledge gap reflects a major challenge to this research: lack of long-term ground-based measurements in locations currently experiencing rapid urbanization. Although lack of air pollution monitoring data is most conspicuous in sub-Saharan Africa (Katoto et al., 2019) it remains an issue throughout much of Asia where available data are largely confined to urban areas, providing little information about rapidly urbanizing *peri*-urban areas on the urban fringe.

The limited available evidence linking changes over time in urban characteristics and air pollution generally show a relationship between economic growth and air pollution in rapidly urbanizing areas. Increasing economic activity in East Asia between 2000 and 2010 was associated with increasing nitrogen dioxide and particulate air pollution, while increasing urban expansion was associated with increasing nitrogen dioxide, a pollutant largely from local sources (Larkin et al., 2016). However, relationships between changes in urban characteristics over time and air pollution appear to depend on city size (Larkin et al., 2016). Similarly, increasing GDP and population in Beijing, China between 1973 and 2013 were associated with increasing particulate air pollution (reconstructed from meteorological data due to lack of measurements) (Han et al., 2016). Particulate air pollution has been identified as one of the pathways by which increasing built up land use over time was associated with poorer cardio-metabolic health in a rapidly urbanizing area of India (Milà et al., 2020). However, these general trends can change dramatically with the introduction of aggressive air pollution control. For example, the introduction of air pollution control policies in several Chinese cities in 2013 led to considerable improvements in air pollution concentrations within a relatively short period of time, despite continued economic growth (Greenstone and Schwartz, 2018). Such an inverted U-shaped function has been observed between per capita GDP and pollution levels for some air pollutants and contexts (Georgiev and Mihaylov, 2015; Keene and Deller, 2013) (i.e. the environmental Kuznets curve) (Grossman and Krueger, 1991). However, debate continues regarding the exact shape of the curve, the applicability in the global context (i.e. export of pollution-intensive processes from wealthy to poorer nations) and with regard to long-lived pollutants (e.g., CO_2) as well as the methodological rigor of some empirical studies (Georgiev and Mihaylov, 2015; Stern, 2004).

While outdoor air pollution generally is higher in urban compared to rural locations, air pollution levels actually inhaled by individuals can be higher in rural areas where access to modern household energy (e.g., electricity, gas) is more limited. In many LMICs, urbanization and economic development are leading to inverse trends with increasing outdoor air pollution over time and decreasing household air pollution as economic development reduces barriers to clean, modern forms of energy for cooking and lighting (Dandona et al., 2017; Landrigan et al., 2018). Accelerated decarbonisation of electricity generation focused on scaling up renewable sources and decentralized systems (e.g., distributed solar and micro-grids) are particularly relevant for increasing access to affordable sustainable energy. These solutions have the potential to simultaneously deliver climate, health, and other co-benefits related to the reduction of poverty, and contributing to economic growth and employment opportunities (Frischmann et al., 2020; Luderer et al., 2019).

3.6. Environmental noise and health

Environmental noise (i.e. unwanted sound) exposure has been linked to a range of adverse health effects including annoyance (Guski et al., 2017), cognitive performance (Clark and Paunovic, 2018), cardiovascular effects (Van Kempen et al., 2018), and sleep (Basner and McGuire, 2018). The WHO has recently developed guidelines for the European Region recommending that average noise exposure from transport sources should not exceed the following values in order to prevent adverse health effects: 53 dB (dB) for road traffic noise; 54 dB for rail; and 45 for aircraft noise. Recommended maximum values for night noise exposure are lower (WHO Regional Office for Europe, 2018).

Environmental noise includes all sources outside of occupational settings, including road, rail, air traffic, construction, as well as other sources, which may be culturally specific (e.g., religious functions, festivals) (Goswami and Swain, 2017). Environmental noise exposure is highly prevalent in urban areas of both high- and low-and-middle- income countries. For example, in Europe approximately 71 million people in urban areas are exposed to road traffic noise at all times above 55 dB (European Environment Agency, 2018). Average noise levels at all hours of the day in Indian cities are often higher than 80 dB weighted to approximate perception by human ear (Goswami and Swain, 2017). Environmental noise levels can be substantially higher in urban compared to rural areas (Albert and Decato, 2017), are positively correlated with traffic and population density (Salter et al., 2015), and higher in mixed-use compared to residential land use (King et al., 2012).

3.7. Urban greenspace and health

Urban greening plays an important role in reducing urban temperature and in adaptation of urban dwellers to climate change (Bowler et al., 2010). Urban greenspace also has more direct effects on health. Homo sapiens are postulated to be evolutionarily bound to nature and as such, the constant contact with natural environments is one of the requirements to achieve healthy growth and living (Wilson, 1984). Urbanization, however, has led to an increasing number of residents of urban areas with limited access to natural environments. Natural environments, including green spaces, have been associated with improved mental and physical health and wellbeing and are increasingly recognized as a mitigation measure to buffer the adverse health effects of urban living (Nieuwenhuijsen et al., 2017). Mechanisms underlying the health benefits of green spaces are yet to be fully established. However, reducing stress, restoring attention, increasing physical activity, mitigating exposure to urban-related environmental hazards including air pollution, noise, and heat, and enriching microbial input from the environment are suggested to be involved (Nieuwenhuijsen et al., 2017).

The health benefits of green spaces have been documented across the life course: from fetal and early postnatal periods through older ages. Higher maternal exposure to green spaces during pregnancy has been associated with improved fetal growth and reduced risk of adverse pregnancy outcomes (e.g., premature birth) and complications (e.g., gestational diabetes, preeclampsia, and depression) (Banay et al., 2017). In children, greenspace exposure has been associated with beneficial anatomical changes in the brain (Liao et al., 2019); enhanced psychomotor (Liao et al., 2019), cognitive, and behavioural development (Amoly et al., 2014; Dadvand et al., 2017, 2015); better mental health (Vanaken and Danckaerts, 2018); improved academic performance (Browning and Rigolon, 2019); and enhanced cardiometabolic status (Dadvand et al., 2018; Markevych et al., 2014). Moreover, experimental studies have demonstrated “therapeutic effects” of playing in green spaces on symptoms of attention deficit-hyperactivity and other neurodevelopmental conditions (Kuo and Taylor, 2004; Taylor et al., 2001; Taylor and Kuo, 2009; van den Berg and van den Berg, 2011). In adults, higher contact with green spaces has been related to reduced risk of a wide range of morbidities including cardiovascular, cerebrovascular, and musculoskeletal problems (Fong et al., 2018); improved mental health (Gascon et al., 2015) and cognitive function (de Keijzer et al., 2016); enhanced perceived general health and wellbeing (Houlden et al., 2018); and reduced risk of mortality (Gascon et al., 2016). An emerging body of evidence has also associated contact with green spaces with improved healthy ageing including decelerating cognitive (de Keijzer et al., 2019a) and physical functioning (de Keijzer et al., 2019b) declines. Despite growing evidence linking green space and health, to date, little evidence is available from urbanizing environments experiencing rapid transition from natural or agricultural to built-up land use (Milà et al., 2020). There is also a growing need to assess the equity considerations of urban green space benefits on health (Anguelovski et al., 2019, 2018).

3.8. Social stress and mental wellbeing

Although urban populations do on average live under improved conditions – they are wealthier and receive better sanitation, contraception and general health care - urban living poses a risk for some major psychiatric diseases. The risk for schizophrenia is about twice as high in urban compared to rural areas, with an exposure-response-relationship for the duration of upbringing in an urban area (Pedersen and Mortensen, 2001). Urban living has been estimated to be a risk factor with a similar effect size as cannabis consumption in individuals with a genetic risk profile for schizophrenia (van Os et al., 2010). Some researchers estimate urban upbringing to account for up to 30% of the overall risk for schizophrenia (Van Os, 2004). Studies also have shown that the risk for schizophrenia changes if an individual moves between urban and rural areas during childhood (Pedersen and Mortensen, 2001). Meta-analysis results showed the prevalence for common mental disorders is higher in urban areas compared to rural environments in high-income countries (Peen et al., 2010). The risk for mood disorders, such as depression, is higher by 39% in urban dwellers and by 21% for anxiety disorders; interestingly, no difference was reported for substance abuse between urban and rural areas. This indicates that urbanicity increases the risk for mental-ill health as opposed to the selection hypothesis, where high-risk individuals self-selectively move to urban environments. However, these findings hold for populations of high-income countries but not for LMICs. A meta-analysis based on WHO data regarding the prevalence of psychotic symptoms (i.e., schizophrenia-like symptoms, such as hallucinations or delusions) from

42 LMICs did not find the urban-rural risk-difference previously shown in high-income countries (DeVylder et al., 2018).

In addition to factors such as air and noise pollution and access to green space, chronic social stress may be an important mechanism by which urban environments affect mental and physical health. Social stress results from social interaction between individuals (or its absence). In the context of urban living, two social stressors are likely to have particular relevance: social density (i.e. overcrowding) and social isolation (i.e. social exclusion, loneliness). If an individual is exposed to both stressors at the same time while lacking an adequate sense of environmental mastery, the combined exposures may become "toxic" (Adli et al., 2017). Social density, social isolation as well as exclusion/discrimination have long been shown to cause increased morbidity and premature mortality in many species including humans (Alvarado et al., 2015; Heinz et al., 2020; Holt-Lunstad et al., 2015; Lin et al., 2015). A notable additional stressor is housing insecurity, which becomes increasingly prevalent with climate-change and economic-crises. Research has documented the relation between poor housing conditions and worse physical and mental health among families and children, including food insecurity, chronic stress, and poor access to preventive health care (Cutts et al., 2011; Duncan and Kawachi, 2018). Chronic social stress may manifest in mental-ill health by adding to other risk factors (e.g., genetic, socio-economic) which predispose to stress-related psychiatric disorders or to lack of access to factors which improve individual resilience and compensation capacities. Hence, the problem seems to arise where the experience of chronic social stress converges with other risk factors for psychiatric diseases due to social isolation, including older age, being a migrant, or living alone. For example, an individual's mental health status was associated with neighborhood-level poverty among residents of a working class area of Berlin, and this association was stronger among individuals with a migration background compared to those with a German background (Rapp et al., 2015).

Functional imaging data indicate that urban living and urban upbringing alter the brain's reactivity (and potentially vulnerability) towards social stress: healthy volunteers show increased activity in stress-processing limbic brain regions (amygdala, anterior cingulate cortex) when performing a social stress task which correlated with city size of

Table 3
Examples of synergies and tradeoffs across determinants of health in urban environments.

	Climate change	Food systems	Land use/transport	Air pollution	Noise	Green space	Social stress (related to mental health)
Demography	− increasing lifetime per capita GHG emissions with increasing life expectancy − increasing number of older people vulnerable to extreme temperature	− living alone linked to unhealthy diet	+ increasing demand for compact cities and transport alternatives to motor vehicles with increasing number of older people	− increasing number of older people vulnerable to health effects of air pollution	− increasing number of older people vulnerable to health effects of noise	+ access to urban green space linked to healthy aging	− living alone linked to social isolation and poorer mental health
Climate change (mitigation, adaptation)		+ mitigation and adaptation linked to improved food security + mitigation and adaptation reduce vulnerability of agricultural workers to high temperature	+ mitigation benefits of active travel, reduced air travel	+ mitigation can deliver large air pollution reductions + improved access to modern household energy (i.e. reduced biomass use) contributes to mitigation	+ reduced road traffic noise with shift from motor vehicles to active travel +reduced air traffic noise from reduced air travel	+ urban greening contributes to adaptation (local cooling) and mitigation (carbon sequestration)	+ adaptation could reduce risk of mental disorders due to high temperature
Food systems			± loss of agricultural land use with urbanization	− food production contributes to air pollution + reducing air pollution improves food security	± interactions expected to be minor	− cropland replaces natural land use + urban gardens contribute to food security	+ social capital & cohesion improve food security + healthy diets improve mental health
Land use/ transport				+ air pollution benefits from reduced motor vehicles	− increasing noise levels with increasing population density and mixed land use	+ converting land use from motor vehicles to green space beneficial for health	+ shifting from motor vehicle to active transport reduces social stress
Air pollution					+ opportunities for co-control due shared sources (e.g., motor vehicles)	± green space may improve or contribute to local air pollution	+ reducing air pollution could improve mental health
Noise						+ green space can be buffer from environmental noise	
Green space							+ green space linked with stress reduction, improved mental health

+ positive interactions for health or options for co-control; − benefits in one area have negative tradeoffs for health; ± both positive and negative interactions likely.

current residence or upbringing (Lederbogen et al., 2011). The same authors reported that urbanicity during upbringing negatively correlates to grey matter volume of the dorsolateral prefrontal cortex. This region has a key function in emotion regulation and has previously shown decreasing volumes with increasing early life stress exposure (Tomoda et al., 2009). Available evidence does not suggest that urban living causes mental problems *per se,* but rather that urban living affects the stress-associated processing of emotions, which can subsequently have a health impact on individuals with an increased risk for mental diseases. To provide recommendations for urban planners and designers to shape urban areas which promote and protect mental health a "charter of neurourbanism" has been recently developed by an interdisciplinary research platform on urban mental health (Neurourbanistik, n.d.).

Determinants of physical and mental health do not operate in isolation; synergies and tradeoffs for health are pervasive. Table 3 highlights some of the ways in which the health determinants discussed above interact in both positive and negative ways. For example, as life expectancy increases the cumulative per capita environmental footprint will increase without ambitious measures to reduce resource consumption (Royal Society, 2012). Older individuals may be more vulnerable to a range of environmental hazards including air pollution, noise, and extreme temperatures. Climate change mitigation and adaptation could be linked to positive synergies for health related to all other health determinants considered in this paper. Several health tradeoffs between food systems and other health determinants are likely. For example, cropland most often replaces natural land use presenting tradeoffs between food security and the health benefits of biodiversity and nature contact. Conversion of agricultural to built-up land use as part of urbanization has been linked to poorer cardio-metabolic health (Milà et al., 2020), but increasing compact, built-up areas may improve opportunities for public and active transport. Food production is a major contributor to air pollution emissions and air pollution can significantly damage crop yields (Sun et al., 2017). Social capital and cohesion can improve food security among vulnerable subgroups (Denney et al., 2017), while healthy diets reduce the risk of mental disorders more generally (Dash et al., 2016). Shifting travel from motor vehicles to active modes would reduce local air pollution and noise while converting public space devoted to motor vehicles to greenspace could deliver health benefits (Mueller et al., 2020, 2017). Not only do health determinants interact with one another, but also with socioeconomic and health inequalities. Interdiscplinary integrated assessments that explictly account for tradeoffs and distributional impacts of interventions provide a more comprehensive understanding of pathways to promote health through sustainable urban development, but also provide critical insights needed to build public acceptance for interventions.

4. New research approaches needed to study links between complex urban systems and health

Cities are complex systems: emergent, far from equilibrium, requiring large inputs to maintain themselves (Rydin et al., 2012). They are open systems in continuous exchange of resources, products and services, people, and ideas spanning multiple scales from individuals, to households, neighbourhoods, cities, and regions (Bai et al., 2016). Health outcomes in urban systems depend on multiple interconnected relationships, which is why interventions often lead to unintended consequences. The dynamic complexity of cities means there is often a time delay between cause and effect, and relationships are often nonlinear, making causal associations difficult to identify with conventional analytical methods. Research to generate new knowledge that responds to the complexity of relationships linking urban systems with health requires approaches that consider multiple spatial scales, sectors, and research disciplines (Acuto et al., 2018), and leverage new opportunities presented by expanding sources of data and emerging research approaches and analytical methods. New knowledge can contribute to: 1) anticipating unintended consequences of interventions; and 2) building public support for health and sustainability actions by explicitly accounting for tradeoffs, justice implications, and socio-physical system interactions.

While new research approaches are needed to advance knowledge, particularly regarding complex interlinkages between urban systems and health, several priorities for promoting health through sustainable urban development are already evident. For example, available evidence supports promoting active and public transport and discouraging private motor vehicle use (Giles-Corti et al., 2016). Similarly, priorities for promoting mental health in urban environments based on existing evidence include: 1) minimizing the experience of uncontrollable social density and provision of quality, affordable housing which provide individuals the opportunity to escape unwanted social density and noise; 2) minimizing social isolation and exclusion, particularly in populations at highest risk for isolation and loneliness; and 3) designing urban public space to facilitate social cohesion and support resilience to social stress (Neurourbanistik, n.d.).

4.1. Science of cities

The "Science of Cities" (Batty, 2013; 2008;; Bettencourt, 2013; Bettencourt et al., 2007) is one research approach that explicitly attempts to address complexities of the coupled socio-physical systems of cities. This approach, which attempts to understand fundamental complex urban processes not specific to health, can often provide ancillary insights into how these processes affect health. "Science of Cities" has used existing patterns in health outcomes across different urban contexts to query the underlying structure and function of urban processes. This research approach starts with the premise that general processes are at play in all cities worldwide and throughout human history, and that these processes have specific, measurable outcomes and can be used to understand and predict outcomes in cities as a result of social processes. This does not imply that city outcomes are deterministic or that the specific contexts and histories are irrelevant. However, it does imply that some urban characteristics can be reliably predicted. Among these are health outcomes, from infections (Patterson-Lomba et al., 2015) and homicides (Gomez-Lievano et al., 2012) to pedestrian fatalities (Chang et al., 2016).

A key example of research in this area is urban scaling. This theory proposes that there is a specific relationship between a city's population and a broad suite of socio-economic and infrastructure-based outcomes. For example, expected urban GDP scales at the 7/6th power with urban population (Bettencourt, 2013; Bettencourt et al., 2007). This means that for a pair of cities in the same time period, with the same national institutions, the larger with double the population of the smaller, the larger city's GDP is expected to be twice the smaller city's GDP plus an additional 15%. This super-linear scaling effect is hypothesized to stem from the broader likelihood of novel interpersonal interactions that are possible in a city with a larger population. In any real-world dataset, there are differences between the numeric outcome expected by theory and the measured outcome. Some share of this difference can be attributed to measurement error, but an important component is a genuine difference between outcome and expectation, or residuals in the model. Outcomes in any specific city are determined by a combination of what is general to all cities and particular to that specific city. The general can be described by theories on urban scaling effects, while the particular is a result of all the characteristics, histories, and local contexts that make individual cities unique.

A core contribution of urban scaling theory is to provide a general understanding of between-city differences due to socio-economic processes, many of which strongly shape health outcomes. Predictions from urban scaling theory can be used for scenario development, public health planning, and policy evaluation. In the limited cases for which data are available (Chang et al., 2016; Gomez-Lievano et al., 2012; Patterson-Lomba et al., 2015), there is evidence that some public health outcomes scale super-linearly with urban population. This result, combined with consistent predictions for ever larger cities in future decades, means that the consequences of urban agglomeration effects should be incorporated into long term epidemic planning strategies.

Another example of complexity science regarding cities and health addresses inequality in urban environments. For example, aggregate urban GDP is only a useful measure of typical access to costly services after the within-city distribution of wealth has been described. There is substantial literature developing measures to characterize within-city heterogeneity in access to infrastructure such as clean water and improved sanitation facilities and other urban services such as education and medical care, many of which are associated with better health outcomes (Brelsford et al., 2017; Gomez-Lievano et al., 2016; Sampson, 2017). Local information on within-city heterogeneity can make a substantial contribution towards planning appropriate and efficient intervention strategies aimed at improving access to these urban services, which can improve local public health outcomes.

4.2. Opportunities from emerging data sources

The environment we live, work, and travel through has a significant impact on health. It influences daily routines, multiple chemical, physical, and social exposures at very different scales: from the type of housing, to the composition of the neighborhood, to the district, the city or even spanning larger entities such as city networks. Remote sensing is one powerful tool for capturing the composition of space at these very different scales. Today's sensors are able to resolve the details of the built structures such as housing types (Wurm et al., 2016) at the same time as they allow to resolve the composition of the neighborhood, the city or the city network (Taubenböck et al., 2014). Sensors allow deriving information beyond the land surface such as on air pollution (Levy et al., 2013) land surface urban heat islands (Li et al., 2009) or light emissions (Shi et al., 2020). The increasing volume and type of remote sensing data is opening unprecedented opportunities to gain insights into how the built, physical, and natural environments within complex urban systems affect health. However, what it does not easily capture are aspects of the social environment, individual behaviors, and perceptions.

A promising direction for future research involves combining strengths of remote sensing with other data sources (e.g., collected through Smart Cities, Internet of Things, sentiment analysis of social media data) to paint a more complete picture, linking the objective knowledge about the built, physical, and natural environment with the subjective information on individuals' experience and perceptions of their environment to more fully understand how these jointly affect health. There is also an essential role for mixed-methods research, including qualitative, interview-based data, to reveal many of the nuanced and interconnected ways in which urban environments shape health; the acceptability of plans and policies to promote sustainability; and how new knowledge is used to inform decision making. These approaches can provide critical insights needed to identify the most effective interventions and processes by which they are implemented to deliver durable improvements in health and reduce social and health inequalities (Anguelovski et al., 2019, 2018).

Rapidly evolving technology in small, wearable sensors is generating opportunities to measure environmental exposures, emotional states, behaviours, and physiological responses on a sufficient scale for health research (Tonne et al., 2017). Combining GPS and wearable sensors, detailed information can now be obtained on individual's location, their physical activity, mode of transport, environmental exposures (e.g., air pollution, noise, UV), physiological responses (e.g., blood pressure, heart rate (variability), glucose levels, body temperature, galvanic skin response), and emotional status over small temporal (seconds) and spatial (m) scales (Donaire-Gonzalez et al., 2019; Kim et al., 2013; Milà et al., 2018; Nieuwenhuijsen et al., 2014; Triguero-Mas et al., 2017; Yeo et al., 2013). This information can be overlaid with information on the built environment, for example from remote sensing, to obtain detailed insights into how multiple dimensions of the urban environment work together to shape individuals' health.

4.3. Potential insights from the Exposome and health impact modelling

The Exposome concept, which aims to link detailed characterization of the external environment (e.g., using remote sensing, wearable sensors) with associated biological perturbations, has considerable potential to provide insights into how urban environments are internalized and ultimately shape health outcomes. The Exposome concept considers environment in its broadest sense, defined as the sum of all non-genetic drivers of health and disease from conception onwards (Wild, 2012). The Exposome aims to capture the diversity, range, and complex interplay between exposures to chemicals, diet, social stressors, physical hazards, and lifestyle factors alongside their corresponding biological responses (Vermeulen et al., 2020). Data on how Exposome patterns vary with urbanization or urbanicity have the potential to more effectively identify targets for interventions to promote health, while better accounting for combined effects of multiple exposures and potential trade-offs. Early Exposome projects initiated mapping the Exposome in Europe (HEALS, n.d.; Maitre et al., 2018; Vineis et al., 2016) and North America (CHEAR, n.d.), pioneering new monitoring techniques, and developing statistical tools to analyse high dimensional Exposome data. The next generation of Exposome projects (e.g., EXPANSE, ATHLETE) are expected to provide detailed insights into how urban environments affect the internal and external Exposome across the life course in Europe as well further development of tools and methods needed to analyse complex mixtures of exposures. Application of Exposome tools to rapidly urbanizing environments in LMICs has the potential to provide much needed insights into how the dynamics of urban development can be shifted to promote health.

Innovative approaches are particularly needed to better understand how interactions between cities and across spatial and governance scales affect health. Health impact modelling has particular potential to address these research gaps and identify the social and economic distributional impacts of pollution flows. For example, a modelling study reported that 41–53% of premature mortality in the United States due to air pollution was due to emissions generated in another state (Dedoussi et al., 2020). Electric power generation was identified as the sector with the largest cross-state impacts: 70% of premature mortality due to this sector occurred outside of the state where emissions occurred. Similar work is needed to explore how cities within the same economic network impact the health of one another's populations through resource and pollution flows. Improved approaches for moving from global, regional, to urban scales are particularly needed. Many of the most relevant policy frameworks addressing the global commons (e.g., UN Framework Convention on Climate Change and the Sustainable Development Goals (SDGs)) are signed and implemented by nations, but have important consequences for health at the local scale. This presents important challenges for modelling impacts of critical policy actions on the health of urban populations.

5. Actions to promote health through sustainable urban development

In many of the most rapidly urbanizing areas of the world (e.g., Asia, Africa), urban areas have yet to be built, leaving a window of opportunity to choose development pathways that meet basic needs and internalize resilience to climate and other risks (Khosla and Bhardwaj, 2019). How urban areas are constructed in the coming decade will influence consumption practices and hence opportunities for sustainable development for decades to come (Seto et al., 2016). We suggest the following actions to promote health through sustainable urban development and to facilitate the emergence of urban areas as sustainable development leaders and laboratories.

5.1. Benchmarking and monitoring

To create healthy, more sustainable urban areas, there is urgent need for integrated planning, focus on evidence-informed policy-making, and the benchmarking and monitoring of the implementation of those policies (Lowe et al., 2019). Increasingly, indicators are being used to monitor progress towards achieving city-wide objectives, with the idea that 'what gets measured gets done' (Giles-Corti et al., 2016). Spatially resolved indicators are particularly helpful, because they can 'unmask' spatial inequalities within cities, which WHO and UN Habitat refer to as 'Hidden Cities' (World Health Organization, 2010). The UN has developed an indicator framework to monitor the achievement of the SDGs. However, an analysis of this framework shows that few of these are 'upstream' indicators of the policies and interventions that will help achieve the goals (Giles-Corti et al., 2019). For example, while reducing air pollution is included in the SDGs, the policies to improve air quality and the interventions to encourage active and public transport modes and reduce the use of private motor vehicles are not. Many cities do not have the policies in place to deliver healthy, liveable and sustainable cities; where policies are available, they are insufficiently ambitious to achieve policy aims; and even modest policy targets are rarely delivered equitably across cities (Lowe et al., 2020; Randhawa and Kumar, 2017). This highlights the need to enhance evidence-informed policy frameworks for cities and the benefits of spatial indicators for benchmarking and monitoring cities. Nevertheless, benchmarking and monitoring, even within countries are often difficult to implement. Spatial data are often not readily available. Where data are available, different cities frequently use different data standards, complicating between-city comparisons.

5.2. Governance and collective action as levers for transformation

Effective governance and collective action are critical levers to realize sustainable urban development and promotion of human health and wellbeing (Independent Group of Scientists appointed by the Secretary-General, 2019). Governance arrangements at the national (and/or state) level should provide cities and urbanizing communities the autonomy and resources to engage in effective, evidence-based and inclusive participatory policymaking with an engaged and informed citizenry. National governments and local authorities should promote investments that ensure access to decent, sustainable and local employment, access to basic services needed for daily living including water, sanitation, transport, clean energy, with effective management of waste and pollution; as well as key social infrastructure such as health and community services and public and green space. This would include designing services that foster sustainable and integrated land use and transport planning, sustainable consumption and production patterns, rapid scaling-up of renewable energy and energy efficiency, with an emphasis on accessibility for all (Independent Group of Scientists appointed by the Secretary-General, 2019). Equity-driven urban planning is needed to ensure that the health of all urban residents, especially the health of socially vulnerable groups (children, women, aging residents, low-income and racial/ethnic minorities) is placed at the center of decisions related to land use, land regulations, and planning of new infrastructure.

Networks of cities and local authorities have emerged as important actors outside of national governments for advancing climate action and promoting health through sustainable urban development, even where national engagement on these issues is lacking. Notable examples include C40 Climate Leadership Group, WHO Healthy Cities, Local Governments for Sustainability (ICLEI) and Eurocities. These networks are able to share best practices, tools, and resources; provide technical support for developing sustainability plans and monitoring progress, and participate in specific campaigns (e.g., Race to Zero to build momentum for a shift to a decarbonized economy in preparation of COP26).

5.3. Conclusion

Urban development can profoundly shape human health as well as progress towards sustainability. Available evidence of these relationships provides enough knowledge to identify broad priorities for promoting health and reducing socioeconomic inequities in urban environments. Nonetheless, new multi-disciplinary approaches are needed to advance knowledge on critical inter-relationships between dimensions of the environment (e.g., social, food, built, natural); consider multiple spatial scales; and identify optimal pathways to promote health, equity, and sustainability goals simultaneously, while minimizing trade-offs. Equally critical is the effective translation of existing and new knowledge to support action towards healthy and sustainable urban development.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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