



Short Communication

The framework of urban exposome: Application of the exposome concept in urban health studies☆



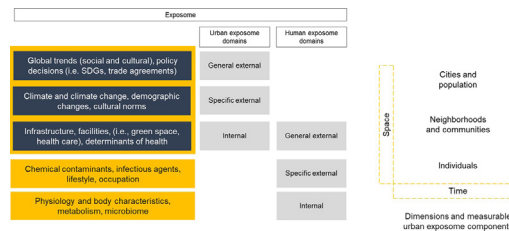
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HIGHLIGHTS

- The urban exposome presents a city-oriented study framework based on the exposome approach used in population studies.
- The urban exposome framework focuses on the spatiotemporal monitoring of environmental and health indicators.
- Primary data collection, and routinely collected data combined define the urban exposome of cities.
- Practical aspects of the urban exposome study framework are discussed in a case study conducted in Limassol, Cyprus.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:

Received 13 December 2017
 Received in revised form 29 March 2018
 Accepted 24 April 2018
 Available online xxxx

Editor: D. Barcelo

Keywords:

Exposome
 Urban health
 Environment
 Disparities
 Climate change
 Metabolomics
 Cities
 Monitoring
 Spatiotemporal
 Indicators

ABSTRACT

Horizontal challenges, such as climate change or the growing populations, and their manifestations require the development of multidisciplinary research synergies in urban health that could benefit from concepts, such as the human exposome. Cities are composed of interconnected systems which are influenced, by global trends, national policies and local complexities. In this context, the exposome concept could be expanded having the city setting in its core, providing the conceptual framework for the new generation of urban studies. The objectives of this work were to define the urban exposome and outline its utility.

The urban exposome can be defined as the continuous spatiotemporal surveillance/monitoring of quantitative and qualitative indicators associated with the urban external and internal domains that shape up the quality of life and the health of urban populations, using small city areas, i.e. neighborhoods, quarters, or smaller administrative districts, as the point of reference. Research should focus on the urban exposome's measurable units at different levels, i.e. the individuals, small, within-city areas and the populations. The urban exposome framework applied in the city of Limassol, Cyprus combines three elements: (i) a mixed-methods study on stakeholders' opinions about quality of life in the city; (ii) a systematic assessment of secondary data from the cancer and death registries, including city infrastructure data; and (iii) a population health and biomonitoring survey. Continuous assessment of environmental and health indicators that are routinely collected, and the incorporation of primary data from population studies, will allow for the timely identification of within-city health and environmental disparities to inform policy making and public health interventions. The urban exposome could facilitate evidence-based public health response, offering researchers, policy-makers, and citizens effective tools to address the societal needs of large urban centers.

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☆ Competing financial interests: None.

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1. Introduction

More than half of the global population nowadays lives in urban areas calling for increased attention to urban population's dynamics, policies and trends ("WHO|Urban population growth," 2016). The current "urban life context", including urbanicity, urbanization and all issues pertaining to urban life under the scope of sustainable development is not one-dimensional (United Nations Human Settlements Programme et al., 2016; Vlahov and Galea, 2002; World Health Organization and United Nations Human Settlements Programme, 2010). Thus, attempts to define cities by the population size fall short of addressing their complexity. Cities are multi-dimensional systems of varying hierarchy. They are further perplexed by their spatiotemporally-dependent population characteristics, which, in turn, are influenced by trends and processes operating at local, national or supranational levels. This is clearly reflected in national, international, and global initiatives that address urban issues, such as the Sustainable Development Goals (SDGs) 3 ("Good health and well-being") and 11 ("Sustainable cities and communities"), the World Health Organization's (WHO) Healthy Cities initiative, the actions of the United Nations' Human Settlements Program (UN-Habitat) or the recent Ostrava Declaration of the 6th Ministerial Conference on Environment and Health (EURO/Ostrava2017/7) (*Goal 3: Sustainable Development Knowledge Platform, 2016, Goal 11: United Nations Partnerships for SDGs Platform, 2016, p. 11, "UN-HABITAT:.. Our Mission," 2016, "WHO|Healthy Cities," 2016*).

In urban settings, health and environmental issues are pressing and need to be addressed using holistic approaches that are accompanied by multi-, inter- and/or trans-disciplinary, sustainable interventions. This view, however, comes with certain advantages and challenges. The main advantage is that multiple urban issues may be tackled simultaneously through the development of synergies that lead to mutual benefits. Moreover, the translation of technical concepts and ideas from one discipline to another hinders the development of interdisciplinary approaches within the field of urban health. Therefore, new concepts and ideas could unify the efforts of dealing with urban issues.

Within this context, global efforts focusing on urban health issues could perhaps benefit from implementing the relatively new concept of the human exposome, i.e., the totality of exposures throughout lifetime that has recently emerged within the field of environmental health sciences (Wild, 2012). The human exposome captures both the entities of totality and integration. Thus, if applied in the field of urban studies and most specifically in urban health, the "urban exposome" could offer researchers, and decision makers with a unifying and global framework to holistically and comprehensively approach the multi-dimensionality of global urban issues. The urban exposome framework could serve for the integration of hierarchically important clusters and networks of urban variables that would feed either into disease risk management or improved urban design and planning strategies or other challenges. The main objective of this work is to provide a definition of the urban exposome and outline its application using a case study.

2. Defining the urban exposome

The human exposome is a dynamic entity that is divided into three major domains, i.e., general and specific external, and the internal domain, keeping the individual as the point of reference, as presented by Wild in 2012 (Wild, 2012). Since then, the human exposome concept has been extended and enriched to include (sub)entities such as the indoor exposome (Dai et al., 2017), the eco-exposome (National Research Council, 2012), the systems biology-based adverse outcome pathways exposome (Escher et al., 2016) and the most recent pollutome defined as the totality of all forms of pollution that have the potential to harm human health (Landrigan et al., 2017). The urban exposome could be seen in one view as the sum of exposures that are related to life in the

city (Probst-Hensch, 2017). However, this definition does not take into consideration how cities and their environments are shaped (from populations, to infrastructures and services) and how they spatio-temporally evolve. Thus, speaking in exposome terms, and keeping *both a global and local perspective*, cities are the result of the integration of interconnected, "living" systems (i.e. infrastructure systems, governance systems, social networks etc.) and their networks, which operate in a dynamic equilibrium and comprise of independent units that constantly interact with the city residents/dwellers. For example, the infrastructure system includes units ranging from water/wastewater/gas distribution system, to transportation, to green spaces, while, in another case the governance system's units are the different institutions that develop and guide policy within the city. These systems are all shaped and managed at various scales of the urban locality from the level of neighborhood, to that of communities, municipalities, to the whole city level.

Therefore, the concept of the "urban exposome" could provide us with the theoretical framework of visualizing and assessing urban life by combining the following domains (Fig. 1), to be used in parallel with those used for the human exposome (Wild, 2012), i.e.,

- **External urban domain:** parameters influencing the development and progress of urban settings that cannot be directly modified by the urban setting itself (i.e. by the local population or by local decision making or governance systems).
 - o **General external urban domain:** global trends (social and cultural), policy decisions (e.g., UN sustainable development goals, international trade agreements).
 - o **Specific external urban domain:** climate manifestations (including climate change impact, e.g., droughts, floods, increasing temperature) and its climate mitigation and adaptation efforts, demographic changes (e.g., population ageing, migration), culture/habits (e.g., local traditions).
- **Internal urban domain:** parameters integral to the urban setting, such as infrastructure (e.g., water/wastewater pipe network, transportation, energy systems), the built environment (indoor air, water and surfaces), facilities (e.g., green space, health care), and major determinants of population health (socioeconomic, psychosocial and others).

Within this context, there is a natural continuum between the urban exposome and the human exposome (Fig. 1). The internal urban domain includes parameters that, although integral to the city, are external to the individuals. Thus, the internal urban domain is in appreciable overlap with the parameters of the general external domain of the human exposome. It follows that the general external domain of the human exposome is accompanied by the specific external domain (i.e. chemical and/or infectious agent exposures, lifestyle/behavior patterns and occupational exposures) as described by Wild (2012). Then, in the individual internal domain of the human exposome, the physiological body attributes and absorption/distribution/metabolism/excretion patterns, may be better characterized by emerging -ome platforms, including the microbiome, metabolome, etc.

Attempts to extend the exposome concept and utility have appeared in the literature. A systems biology-based cellular toxicity emphasis in a recent definition of the exposome further extends the exposome utility and theoretical framework (Escher et al., 2016), while the eco-exposome concept was designed to include broader ecological issues in the human exposome agenda (National Research Council, 2012). Besides the theoretical efforts, funding agencies and research organizations already support exposome research in various ways. In the USA, the cross-fertilisation between two funding organizations, such as the National Institutes of Health (more focus on the internal domain of the exposome) and the National Science Foundation (more focus on the general and specific external domains of the exposome) with activities that lie at the interface of the exposome could pave the way for major scientific advances and breakthroughs. Similarly in Europe

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