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Urban Management and Health: New methodologies for old challenges

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Gestão Urbana e Saúde: Novas metodologias para antigos desafios

RESUMO

Objetivo - Analisar criticamente as interfaces entre infraestrutura urbana e salubridade, a partir de uma revisão da literatura nacional e internacional, com foco na identificação e avaliação de soluções inovadoras — como infraestrutura verde e ruas completas — que respondam aos desafios contemporâneos impostos pelas mudanças climáticas, pelo crescimento urbano acelerado e pelos efeitos da pandemia da Covid-19.

Metodologia - O estudo foi conduzido por meio de uma revisão da literatura científica nacional e internacional sobre infraestrutura urbana e salubridade, com foco na análise de três metodologias complementares: (i) proposição de indicadores que buscam equilibrar a infraestrutura cinza com as demandas por infraestrutura verde e azul em cidades compactas; (ii) avaliação da funcionalidade das vias urbanas para a implementação de "ruas completas", considerando as funções de mobilidade, ambiente e convivência; e, por fim, (iii) monitoramento espaço-temporal contínuo de indicadores quantitativos e qualitativos que moldam a saúde das populações urbanas.

Originalidade/relevância - O estudo se insere em uma lacuna teórica relacionada à necessidade de integrar evidências científicas ao planejamento urbano, especialmente no contexto latino-americano, onde ainda são escassas as análises que associam infraestrutura urbana, saúde e sustentabilidade de maneira integrada e operacional.

Resultados - As metodologias analisadas demonstraram-se eficazes para orientar intervenções urbanas que promovam a infraestrutura verde, a melhoria da mobilidade urbana e a promoção da saúde pública. Destacam-se exemplos de aplicações bem-sucedidas dessas abordagens no planejamento urbano e ambiental.

Contribuições teóricas/metodológicas - O estudo reforça a importância da integração entre indicadores ambientais e urbanos no planejamento, ampliando as bases teóricas e metodológicas para o desenvolvimento de cidades mais resilientes e saudáveis.

Contribuições sociais e ambientais - Evidencia-se a urgência de incorporar soluções baseadas na natureza e metodologias integradas no planejamento urbano, com impactos positivos na saúde pública, na qualidade ambiental e no bem-estar social, especialmente diante das crises climática e sanitária contemporâneas.

PALAVRAS-CHAVE: Saúde pública. Planejamento Urbano. Sustentabilidade Urbana.

Urban Management and Health: New Methodologies for Old Challenges

ABSTRACT

Objective - To critically analyze the interfaces between urban infrastructure and health, based on a review of national and international literature, focusing on identifying and evaluating innovative solutions - such as green infrastructure and complete streets - that respond to contemporary challenges posed by climate change, rapid urban growth, and the effects of the Covid-19 pandemic.

Methodology - The study was conducted through a review of national and international scientific literature on urban infrastructure and health, focusing on the analysis of three complementary methodologies: (i) proposing indicators that seek to balance gray infrastructure with the demands for green and blue infrastructure in compact cities; (ii) evaluation of the functionality of urban roads for the implementation of “complete streets,” considering the functions of mobility, environment, and coexistence; and, finally, (iii) continuous spatiotemporal monitoring of quantitative and qualitative indicators that shape the health of urban populations.

Originality/Relevance - The study fills a theoretical gap related to the need to integrate scientific evidence into urban planning, especially in the Latin American context, where analyses that associate urban infrastructure, health, and sustainability in an integrated and operational manner are still scarce.

Results - The analyzed methodologies proved effective in guiding urban interventions that promote green infrastructure, improve urban mobility, and promote public health. Examples of successful applications of these approaches in urban and environmental planning stand out.

Theoretical/Methodological contributions - The study reinforces the importance of integrating environmental and urban indicators in planning, expanding the theoretical and methodological bases for the development of more resilient and healthy cities.
Social and Environmental contributions - It highlights the urgency of incorporating nature-based solutions and integrated methodologies into urban planning, with positive impacts on public health, environmental quality, and social well-being, especially in the face of contemporary climate and health crises.

KEYWORDS: Public health. Urban planning. Urban sustainability.

Gestión Urbana y Salud: Nuevas Metodologías para Viejos Desafíos

RESUMEN
Objetivo – Analizar críticamente las interfaces entre infraestructura urbana y salubridad, a partir de una revisión de la literatura nacional e internacional, con énfasis en la identificación y evaluación de soluciones innovadoras —como la infraestructura verde y las calles completas— que respondan a los desafíos contemporáneos impuestos por el cambio climático, el acelerado crecimiento urbano y los efectos de la pandemia de la Covid-19.
Metodología – El estudio se llevó a cabo mediante una revisión de la literatura científica nacional e internacional sobre infraestructura urbana y salubridad, con énfasis en el análisis de tres metodologías complementarias: (i) la propuesta de indicadores orientados a equilibrar la infraestructura gris con las demandas de infraestructura verde y azul en ciudades compactas; (ii) la evaluación de la funcionalidad de las calles para la implementación de "calles completas", considerando las dimensiones de movilidad, ambiente y lugar; y (iii) el monitoreo espacio-temporal continuo de indicadores cuantitativos y cualitativos que moldean las condiciones de salud de las poblaciones urbanas.
Originalidad/Relevancia – El estudio se inserta en la brecha teórica relacionada con la necesidad de integrar evidencia científica en la planificación urbana, especialmente en el contexto latinoamericano, donde aún son escasos los análisis que asocien infraestructura urbana, salud y sostenibilidad de forma integrada y operativa.
Resultados – Se demuestra que las metodologías analizadas son eficaces para orientar intervenciones urbanas que promuevan la infraestructura verde, mejoren la movilidad urbana y fomenten la salud pública. Se destacan ejemplos de aplicaciones exitosas de estos enfoques en la planificación urbana y ambiental.
Contribuciones Teóricas/Metodológicas – El estudio refuerza la importancia de integrar indicadores ambientales y urbanos en los procesos de planificación, ampliando las bases teóricas y metodológicas para el desarrollo de ciudades más resilientes y saludables.
Contribuciones Sociales y Ambientales – Se evidencia la urgencia de incorporar soluciones basadas en la naturaleza y metodologías integradas en la planificación urbana, con impactos positivos en la salud pública, la calidad ambiental y el bienestar social, especialmente frente a las crisis climática y sanitaria contemporáneas.

PALABRAS CLAVE: Salud pública. Planificación Urbana. Sostenibilidad Urbana.

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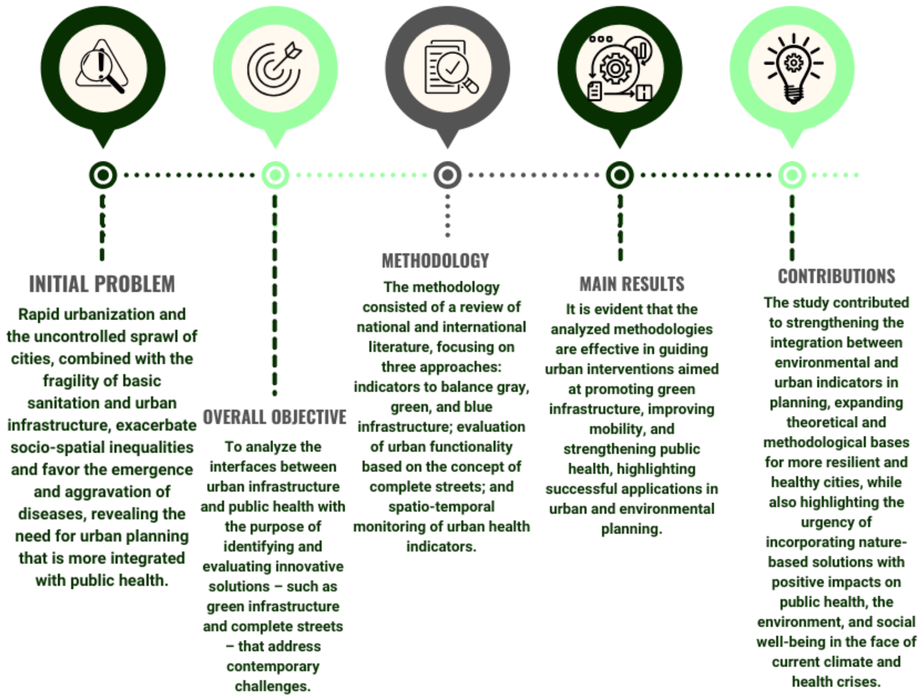
GRAPHIC SUMMARY



1 INTRODUCTION

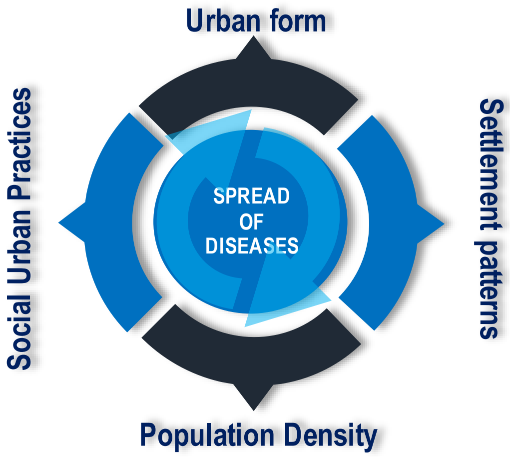
According to a report by the United Nations (UN-WUP, 2019), the urbanization process of the world population reached an unprecedented milestone in 2018, with 55% of people living in cities, surpassing the number of rural dwellers, in contrast to the figure of 30% in 1950. Experts point out that this number is expected to reach 68% of residents in urban centers by 2050. Since the last century, large cities have been expanding (sprawling) spatially without the urban population growing at the same rate. This is the case, for example, in the city of Los Angeles, California: between 1970 and 1990, its population increased by about 45%, while its urban area expanded by 300% (Ragazzo and Lima, 2015). Although it emerged as a way to eliminate some of the problems triggered by the rural exodus to global cities, which occurred mainly after the industrial revolution, this urban sprawl has led to negative externalities, such as: increased traffic congestion due to dependence on motor vehicles for transportation; environmental deterioration; increased cost of providing urban infrastructure; reduced human interaction; socioeconomic segregation; and damage to the health of the population (Silva et al., 2015).

According to Ling (2020), throughout much of the history of cities, urban planning has been linked to sanitation, given that this was one of the first major problems of urbanization. By 1858, Paris was already undergoing transformation with Haussmann's remodeling, opening wide avenues and demolishing slums. The main objectives were to bring light, air, clean water, and sanitation to the old medieval city, as well as the military function of reducing urban conflicts. In the United Kingdom, one of the first documents addressing urban planning and construction was the Public Health Act of 1875, which, among other things, attempted to prevent sewage waste in public areas of the city.

According to Bollyky (2019), in 1857, no city in the US had a sanitary sewage system; by 1900, 80% of Americans living in cities were served by a sewage system, and the percentage of urban households in the US supplied with filtered water increased from 0.3% in 1880 to 93% in 1940. Improved access to filtered and chlorinated water may have been responsible for almost half of the decline in mortality in US cities between 1900 and 1936, according to the author. Thus, it is possible to say that the greatest changes in the urban status quo occur during outbreaks of contagious diseases (Sample, 2012), generating a cyclical relationship in which, with improved health and sanitation, fewer people who moved to urban areas in search of economic rewards died, and the population of these cities expanded and prospered.

In this context, factors such as urban form, settlement patterns, population density, and urban social practices (Figure 1) are interrelated and influence the expansion of cities, leading to the emergence of diseases.

Figure 1 - Shows that factors such as urban form, population density, settlement patterns, and social practices have a cyclical relationship with the spread of disease.



Source: Own elaboration (2021)

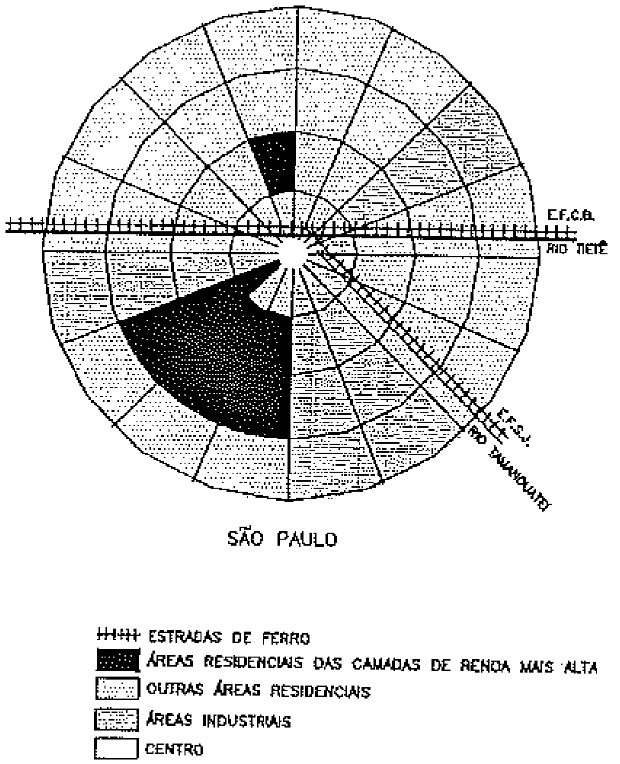
In fact, even with migration, large cities in the 19th and early 20th centuries grew slowly in population by today's standards. This rate only began to accelerate when cities invested in urban infrastructure—such as sanitation, drinking water systems, and policies that prohibited crowded tenements and poor working conditions in factories—which could help overcome the burden of respiratory and waterborne diseases (Bollyky, 2019).

In São Paulo, urban and sanitary reforms occurred primarily due to unsanitary conditions and disease resulting from demographic expansion, driven by the arrival of immigrants, peasants, freed slaves, and farmers to the city, attracted by coffee production and emerging industrialization. In 19th-century Europe, major cities had already implemented sanitation practices in urban areas, even before São Paulo, driven by population growth resulting from industrialization (Domenics, 2014). According to Domenicis (2014, p. 39), "London was the first city to implement effectively modern urban intervention projects, such as water, gas, and sewage networks."

Nevertheless, although the highest income classes in cities tend to concentrate in a specific region of the city, where investments and urban benefits are also concentrated (Villaça, 2012), social segmentation in the urban fabric with differentiated access to resources and infrastructure can influence the spatial and temporal distribution of diseases (Johansen; Carmo and Alves, 2016) and, as a consequence, the social groups most affected are the poorest, highlighting the relevance of the chain of signifiers: misinformation–poverty–segregation–disease (Pascual, 2017; Simão, 2020).

In intra-urban spaces, according to Silveira, Lapa, and Ribeiro (2007), segregation is seen in both social and physical-territorial aspects as an integral part of the overall process that determines the production and appropriation of means of collective consumption and mechanisms for land price formation. For the authors, one of the characteristics of medium and large Brazilian cities is the spatial segregation of residential neighborhoods, where different social classes tend to concentrate in distant areas or sectors of the city (Figure 2).

Figure 2 – Hoyt's urban structure model applied to the city of São Paulo at the beginning of the 20th century.



Source: Vilaça (2000, apud Garcia & Cardoso, 2019)

Urban segregation can be understood, for example, with Homer Hoyt's (1933) model of intra-urban sectorization. Figure 2 on the Radical Cartography website shows a map of the distribution of the higher-income population in the city of Detroit in the USA. Many cities tend to concentrate the wealthiest classes in specific areas of the urban space, which attracts investments in urban infrastructure, for example.

Regarding urban infrastructure, population density affects the efficiency of the provision and maintenance of urban infrastructure and services. According to Acioly and Davidson (1998), low densities mean long infrastructure networks, large spatial dimensions for few consumers, and therefore high per capita investment costs in both installation and maintenance and operation. Conversely, high densities—above what was planned—lead to problems of infrastructure network saturation and urban inefficiencies. In this context, the road system, storm water drainage, and water supply and sewage systems become obsolete, which affects the health of cities.

Mendes (2020) argues that if urbanization brings increasingly complex challenges, the choices to mitigate the problems arising from this process are also complex, as they result in public policies with clear implications for spatial, social, economic, cultural, and environmental relations (see vicious and virtuous cycles in cities, Figure 3).

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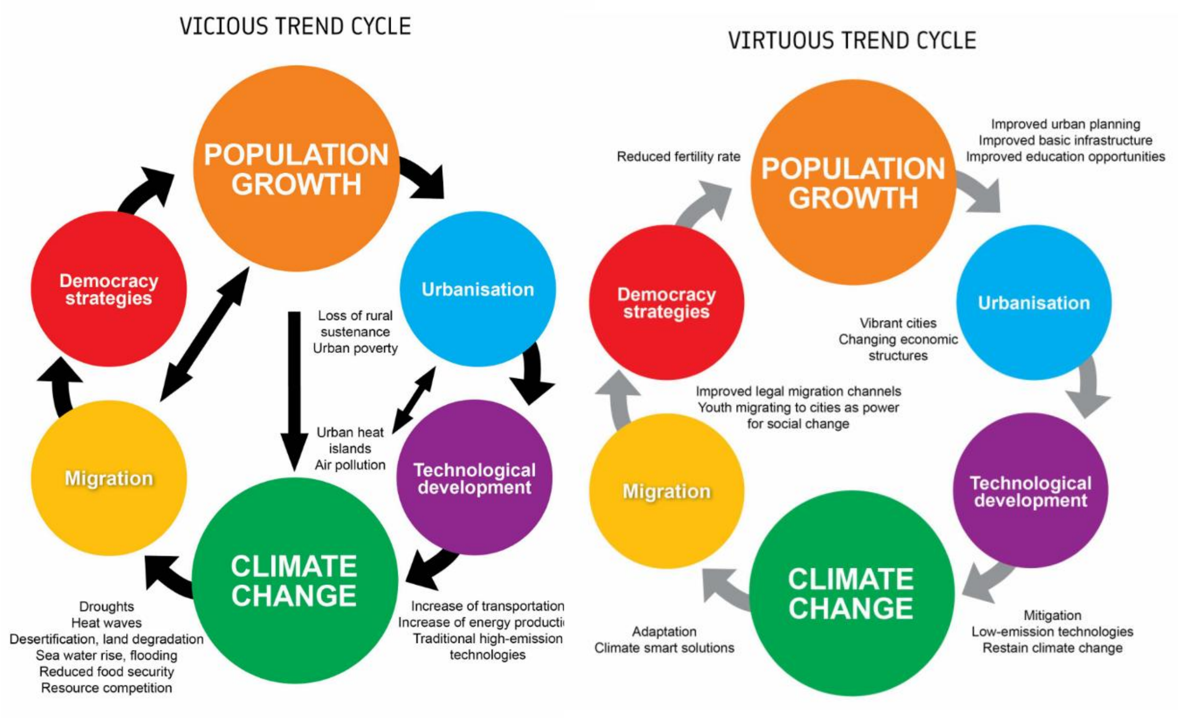
Figure 3 – Vicious and virtuous cycles of good practices in cities.



Source: Vastapuu et al. (2019)

Thus, if urban centers are places of encounter, opportunity, and diversity, on the other hand, because they are connected to a global system, they are also an environment conducive to the rapid spread of epidemics such as the one we are currently experiencing, caused by the SARS-CoV-2 virus. Given that access to basic urban services, decent housing, respect, and appreciation of human rights in cities are all long-recognized problems, the object of study in this work is the city and its relationship with health.

A review of the most current literature on good practices in urban and environmental planning was undertaken to understand the relationship between the occurrence of diseases and urban development, with a focus on urban infrastructure systems, especially those related to green infrastructure (GI) and blue infrastructure (water in urban areas) and complete streets, in the Brazilian and international context of scientific production on the subject.

This study provides an initial review of cities and urban infrastructure in relation to health, exposing the difficulties and challenges of urban and environmental planning. It also addresses research directions and advances in the systemic understanding of the topic and its planning. Three methodologies are analyzed, and examples of applications and results achieved are presented and discussed in the final part of the study.

2 INITIAL REFLECTIONS AND CONCEPTS ON URBAN INFRASTRUCTURE AND HEALTH

Griffiths, Bohmann, and Burdett (2017) report that in the short span of 25 years, cities have grown faster than ever before. “Fishing villages have become megacities, and deserts have become urban playgrounds, they report.” The speed and scale of this transformation are unprecedented. By 2030, five billion people will be living in cities. How cities are planned will determine how they grow (Figure 4). According to the authors, the city of Los Angeles consumes 14 times more space per person than Hong Kong. Accommodating the world's urban growth by 2030 at Los Angeles density levels would cover almost half of the European Union. At Hong Kong's density, the global urban population could fit into the northern half of Italy.

According to Griffiths, Bohmann, and Burdett (2017), low-density expansion has negative impacts on resources and infrastructure, increasing travel times and the length of public service networks, while compact cities are more socially and environmentally sustainable.

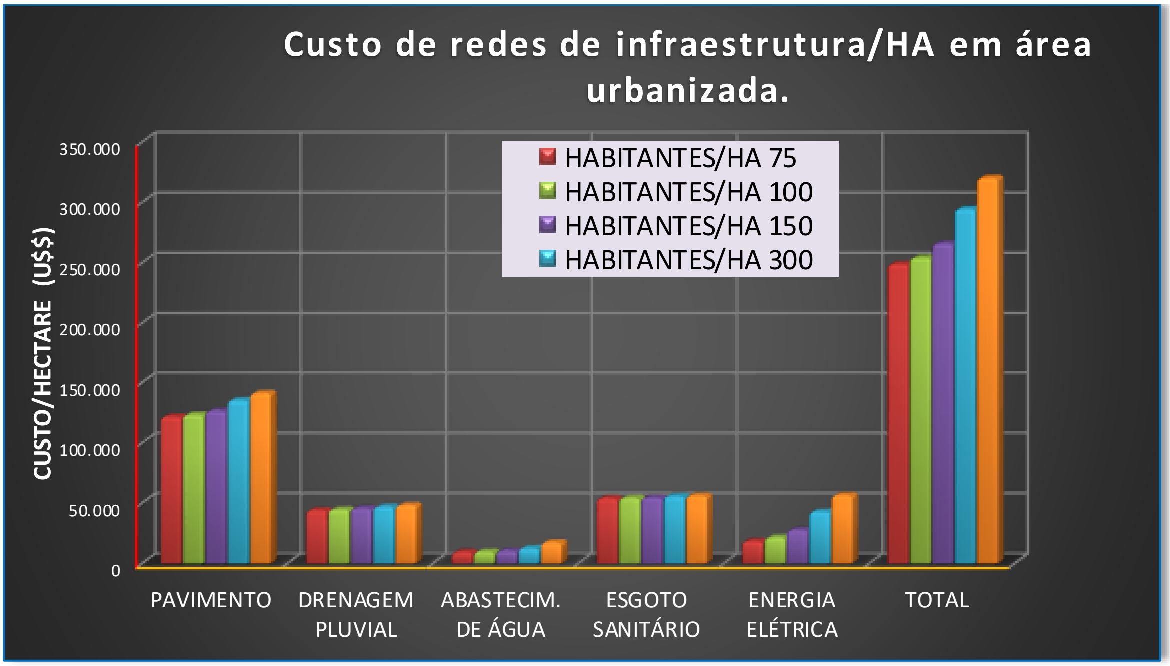
Figure 4 – Above, the city of Shanghai; below, Mexico City.

Source: LSE Cities (2017)

From 1990 to 2015, Shanghai's population increased from 8.606 million to 23.482 million, and more than 35,000 eight-story towers were built. With 22 million inhabitants, Mexico City experienced informal growth from 15.642 million to 21.782 million inhabitants between 1990 and 2015, expanding far beyond the city limits and exceeding its infrastructure and resources (Macrotrends, 2023).

The relationship between urban form and population density is a fundamental dynamic of urban sustainability. Higher population densities — up to approximately 600 inhabitants per hectare, according to some studies, especially for medium-sized cities—can facilitate more efficient public transportation, walking, and cycling, more integrated services, and promote urban vitality. Conversely, lower densities and urban sprawl impact all forms of urban infrastructure, while contributing to pollution and social exclusion. In addition to density, patterns of occupation and urban land use are factors considered in urban sustainability. In this sense, Ojima (2007) observes that there is a significant association between the negative effects of spatially separated occupation centers characterized by the fragmentation of urban spaces. Among the social aspects related to urban dispersion are the increase in social costs (Figure 5) for the provision of public services—especially a higher cost per household—and the potential increase in dependence on motorized transport, as both would be conditioned by the greater or lesser dispersion of the urban network (Ragazzo and Lima, 2015; Silva et al., 2016).

Figure 5 – Cost of infrastructure networks/HA in urbanized areas.



Source: Own elaboration (2021)

The cost per hectare of urbanized land varies little based on the capacity of infrastructure networks. Thus, for an occupancy of 75 inhabitants/ha, this cost is approximately US$250,000, but for an occupancy of 600 people/ha, it is US$320,000 on average. However, when this cost is converted into a per capita calculation, the situation changes dramatically. In the first case, the cost per urbanized hectare is US$3,334 per individual, which is the average Brazilian occupational density situation. In the second situation, the cost is reduced to US$533 per resident (Silva, Silva, and Nome, 2016).

According to Silveira (2011), urban dispersion seems to have no barriers, where the forces are predominantly those of distension, and the growing demands for mobility and the excessive use of cars aggravate the process. Beyond the peripheral growth pattern of the past, linked to the less affluent social classes and marked by the irregular appropriation of spaces, the features of the new urban design simultaneously point to the expansion of popular, so-called "formal" housing developments and the expansion of luxury gated communities (Figure 6).

Rapid urbanization, water pollution, climate change, and inadequate maintenance of water and sewage infrastructure in cities can lead to flooding, water shortages, adverse health

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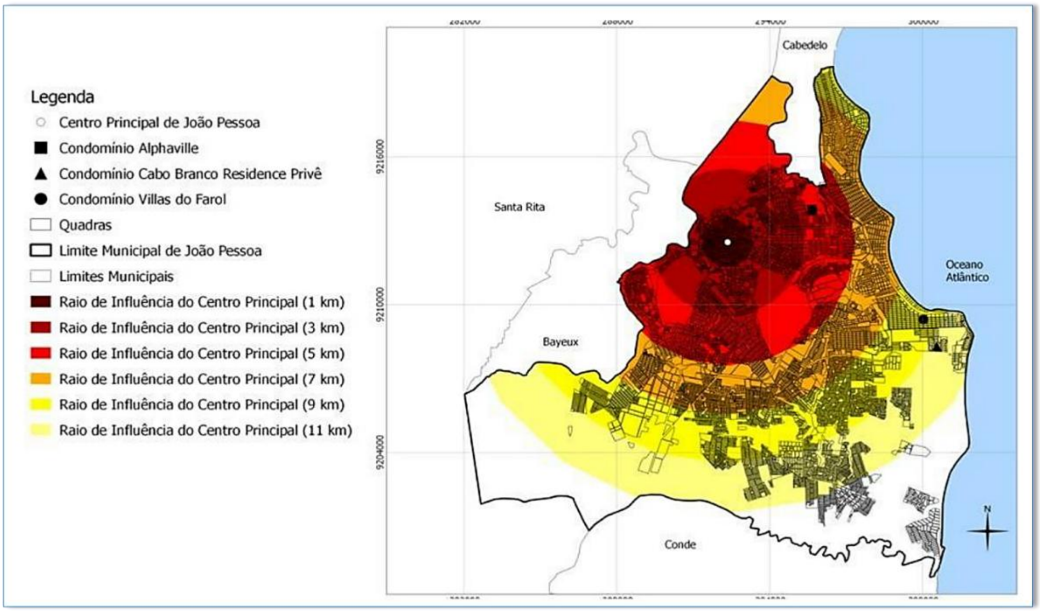
effects, and rehabilitation costs that overwhelm a city's resilience of cities (Koop and Leeuwen, 2015). With 80% of global GDP produced in cities, according to a UN-HABITAT report (2016), global environmental pressures and the long-term preservation of natural ecosystems are largely determined by urban systems.

In Brazilian metropolitan areas, the increased incidence of flooding, lack of sanitation, and difficulties in solid waste management, along with air pollution and the deterioration of water resources, have an increasing impact on the health of the population (Jacobi and Peres, 2016), particularly among low-income residents of slums, who suffer from flooding, water shortages, disease outbreaks, and other health risks (Fajersztajn et al., 2016; Soares et al., 2014).

Figure 6 – Radius of influence of the main center in relation to luxury condominiums in João Pessoa, Paraíba.

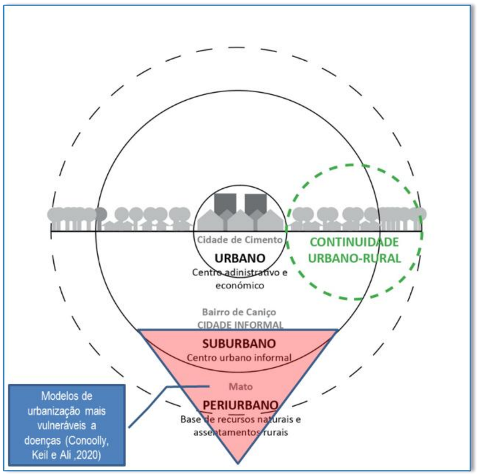


Source: Lira et al. (2020)

According to Connolly, Keil, and Ali (2020), contemporary patterns of extended urbanization fundamentally change the vulnerability of cities to infectious diseases in ways that differ from those historically associated with urbanization. Such processes of urban expansion are linked to the ubiquitous reorganization of the global urban periphery through complex processes of displacement of central populations to the urban edges and the creation of new functional centralities (jobs, infrastructure, and densities) far from the traditional core.

Connolly, Keil, and Ali (2020) argue that rapid urbanization, or densification, is seen as a facilitator of the spread of infectious diseases. The expansion of urban areas and the fluid relationships between urban and rural environments increase the likelihood of infectious disease outbreaks. This is partly because urban expansion can expose suburban and peri-urban areas (Figure 7) to higher levels of biodiversity (and sources of disease) than those found in central urban areas. As an example, the authors cite the most significant global disease outbreaks in recent years: SARS, which originated in China, and Ebola in Africa. To confirm this hypothesis, the current COVID-19 pandemic also originated in China, probably from wild bats.

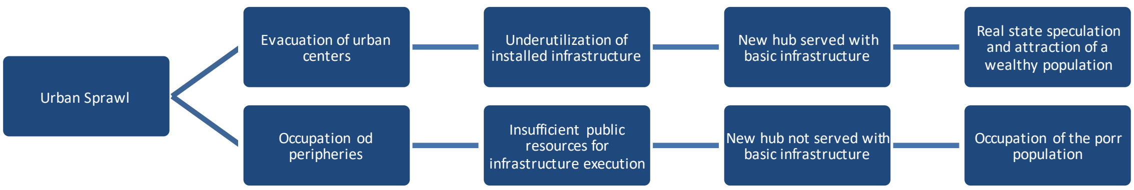
Figure 7 – Schematic diagram of the pattern of urban expansion with suburban and peri-urban areas.



Source: Veríssimo (2013)

In this sense, Connolly, Keil, and Ali (2020) state that although suburban areas are popularly understood to be low-density areas, these processes of extended urbanization in developing regions generally consist of densely populated "new cities" of skyscrapers or high-density informal peri-urban settlements that provide perfect scenarios for the spread of microbes and infectious diseases. In this process, so-called gentrification (Figure 8) may occur, which can be understood as the appreciation of urban areas through investments. In this process, gentrification (Figure 8) may occur, which can be understood as the appreciation of urban areas through investments in infrastructure and facilities, which drive poorer populations out of certain parts of the city. The first observations and evidence of this phenomenon occurred in London in the 1960s.

Figure 8 – Schematic diagram of the pattern of urban expansion with suburban and peri-urban areas.



Source: Own elaboration (2021)

3 RESEARCH DIRECTION AND ADVANCES FOR URBAN PLANNING ON THE UNDERSTANDING OF THE CITY-INFRASTRUCTURE-HEALTH INTERFACE

In a recent article, Bollyky (2019) stated that "health has shaped the history of cities, but it is cities that will define the future of global health and economic development." According to the author, there is no quick or easy solution for creating sustainable urban infrastructure in

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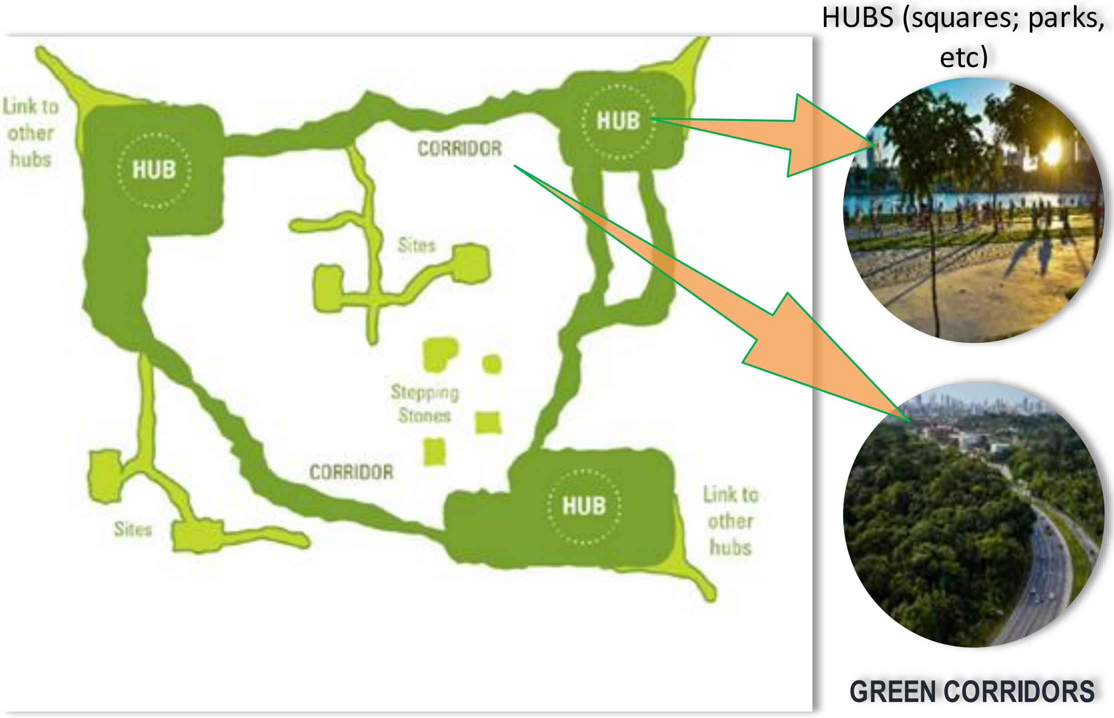
poor cities around the world that have already been built. In this sense, some approaches such as green infrastructure (GI) and complete or shared streets have emerged as sustainable solutions, in opposition (at least in the conceptual sense) to urban planning based on "gray" infrastructure.

3.1 Green Infrastructure

There is a significant number of definitions available for the concept of GI (Green Infrastructure). For example, Benedict and McMahon (2006) point out that green infrastructure emerged as a promising framework for understanding, managing, and enhancing the multiple benefits provided by nature, particularly in highly fragmented landscapes. GI can also be understood as a network (Figure 9), favoring multifunctional open spaces that allow green infrastructure to be used in various ways and dimensions, such as green belts, ecological corridors, linear parks, formal parks, gardens, woods, green corridors, watercourses, among others. It encompasses all environmental resources and, therefore, a green infrastructure approach also contributes to sustainable resource management (Davies et al. 2006).

Figure 9 – Green infrastructure.



Source: Adapted from Benedict and McMahon (2006)

It is true that in recent years, green infrastructure has been increasingly associated with water resource management, especially in urban areas. In stormwater management, GI practices such as Best Management Practices (BMP), Low Impact Development (LID), and Sustainable Urban Drainage Systems (SuDS) have gained popularity and have been characterized

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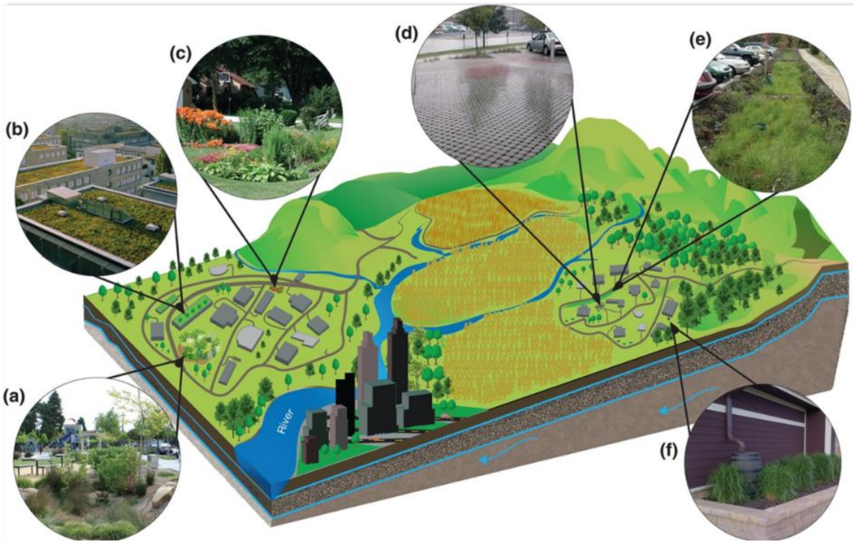
by smaller-scale stormwater treatment devices, such as bioretention systems, green roofs, and permeable pavements (Figure 10).

Figure 10 – Schematic of low-impact development (LID) practices at the watershed scale: (a) bioretention system, (b) green roof, (c) rain garden, (d) permeable pavements, (e) a bioswale, and (f) rain barrel (Not to scale).



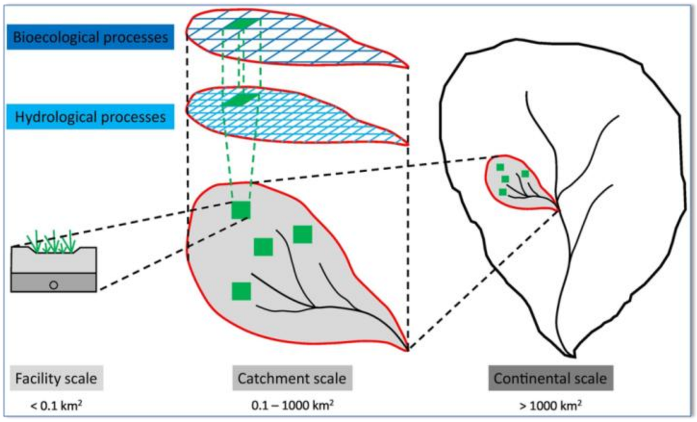
Source: Golden and Hoghooghi (2018)

Each of these definitions uses a series of socioeconomic and ecological principles, landscape resources, and alternative approaches to landscape planning to frame IV, how it should be developed, and what benefits it should provide. The key principles of this process promote social, economic, and environmental benefits within an integrated planning approach that allows different stakeholders to shape the ways in which they develop and manage the landscape (Mell, 2017).

A concrete example of the application of these principles can be seen in the study by Silva et al. (2023), who proposed an intervention plan for Permanent Preservation Areas (APPs) along the Espinharas River in Patos, Paraíba. The study demonstrates that integrated management of water resources and urban territory, focusing on requalifying riverbanks, can mitigate environmental impacts and hydrological risks while increasing ecosystem and social benefits for the population. The articulation between green infrastructure and participatory planning strategies thus reinforces the relevance of sustainable and multifunctional approaches aimed at promoting urban health.

According to Zhang and Chui (2019), understanding the hydrological and bioecological benefits of IV practices is challenging because they vary in form and span multiple scales. As shown in Figure 11, distributed IR practices range from the installation scale (0 to 0.1 km) to the watershed scale (0.1 to 1000 km) and the continental scale (> 1000 km). IV systems at larger scales, therefore, affect hydrological, ecological, and biological regimes more broadly. However, due to the different intrinsic natures of hydrological and bioecological benefits, IV practices are sensitive to changes in spatial scale to varying degrees.

Figure 11 – Diagram showing IV practices on the scale of the installation to river basins and continental basins.



Source: Zhang and Chui (2019)

According to Artmann et al. (2017), urban green spaces are areas within an urban environment with any amount of vegetation, such as parks, urban agriculture, urban forests, residential gardens, or green roofs. The concept of green infrastructure stands out as a strategic planning approach with multiple objectives, implementing these different types of urban green spaces at various scales (as outlined above). In the view of the authors cited above, the benefits of green areas should be provided where demand exists, mainly because the effects of green spaces are spatially confined. However, especially in compact cities, the supply of ecosystem services is lower than their demand. In particular, there is a lack of integrative concepts for urban research and planning practices to address compact and green cities.

In this context, the study by Andrade et al. (2022), conducted in Sousa–PB, demonstrates that the presence and positive perception of green areas are directly associated with urban quality of life. This evidence reinforces the relevance of methodologies that articulate environmental and social indicators as urban management strategies aimed at promoting health.

3.2 Complete Streets

Great ideas can forever change the destiny of cities when implemented in cement, steel, and stone, challenging existing perceptions, values, and paradigms about the meaning of progress, modernity, and success. They embody the bold visions of their creators and challenge prevailing perceptions about urban life. In this context, traditional ideals of urban life are changing as environmental and economic pressures on cities for more sustainable solutions grow (Maassen and Galvin, 2019).

According to Maassen and Galvin (2019), the car-oriented urban design model is under pressure, as many cities are experiencing an increase in traffic accidents and deaths, days of poor air quality, and traffic jams. In the United States, the concept of "complete" or "shared" streets (Figure 12) was formally introduced in 2005 by a national coalition and radically challenged the domination of public space by automobiles. Less comprehensive (and therefore less intimidating) than Barcelona's superblocks, the model gives pedestrians, cyclists, and public transportation users the same priority as drivers of individual motor vehicles. According to the authors cited above, different versions of this approach are emerging worldwide, such as the Shared Space Program in Auckland, New Zealand; "tactical urbanism" in Porto Alegre, Brazil; and the redesign of Telegraph Avenue in Oakland, California. The specifics vary, but generally these projects include elements such as an active, mixed-use urban landscape, street furniture for pedestrians, and green infrastructure.

Figure 12– Intersection of João Alfredo St., in Porto Alegre, Brazil, before and after a Complete Streets intervention.

Source: Maassen and Galvin (2019)

Santos, Pasqual, and Corrêa (2020) argue that small-scale, rapid, and affordable changes to road design can significantly impact cities. Tactical urbanism, which can include painting new pedestrian areas, installing low-cost street furniture, or creating parklets (areas adjacent to sidewalks where structures are built to create spaces for leisure and socializing), can serve as catalysts for broad change, especially when communities are engaged (Figure 13).

Figura 13– Complete Streets – Miguel Calmon St., Salvador, BA - Fotos: Rafael Martins/WRI Brasil.

Source: WRI Cities (2019).

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In a recent article, Lima, Nerbas, and Silva (2020) highlight the potential of walkability, associated with green infrastructure, as an important strategy in the redevelopment of consolidated urban centers. This strategy can benefit the neighborhoods, as walkability provides a significant improvement in quality of life, urban vitality, community health, interpersonal relationships, as well as less air and noise pollution and a greater sense of belonging to the city. The authors argue that, the redevelopment of consolidated urban centers should seek to optimize existing buildings, equipment, and infrastructure, which can have positive implications for environmental sustainability. Additionally, they recommend that the redevelopment of urban sectors be based on the concept of complete streets, which takes into account the principles of sidewalks and their elements: universal accessibility and safe connections, adequate dimensions, quality paving, efficient drainage, efficient public lighting, and attractive spaces through the use of urban furniture and vegetation.

4 NEW METHODOLOGIES FOR THE STUDY AND UNDERSTANDING OF URBAN PLANNING ON GREEN INFRASTRUCTURE, COMPLETE STREETS, AND HEALTH IN THE URBAN ENVIRONMENT

Based on the initial concepts outlined in item 3, three current methodologies are presented for studying and understanding urban and environmental planning on the topics of green infrastructure, complete streets, and health in urban areas, as well as their possible implications for improving the healthiness of the urban environment.

4.1 Conceptual framework for compact and green cities (ARTMANN et al., 2017)

Compact cities are spatial forms characterized by high density and good public transportation provision, and are usually conceived as an antagonistic model to urban sprawl. Their policies focus on solving urban problems such as energy and resource waste, air pollution, accessibility, social segregation, among others.

However, one of the biggest problems that compact cities face is the low proportion of urban green spaces. Thus, the objective of the work by Artmann et al (2017) is to develop a systemic conceptual framework for compact and green cities, associating concepts of sustainable growth and green infrastructure, based on the premise that these are mutually consolidable. The study suggests that, in order to develop a systemic approach to compact green cities, there is a need to balance the aspects relevant to both aspects, as shown in Figure 14.

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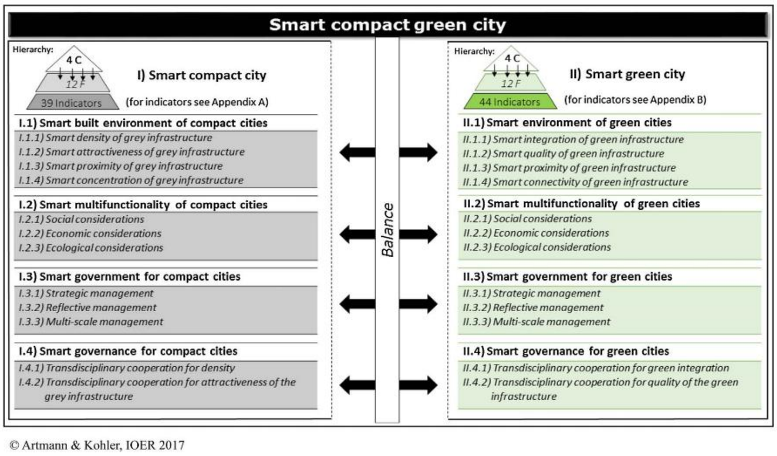
Figure 14– Characteristics (C) and factors (F) for the systemic structure of the smart-compact-green city.



Source: Artmann et al., (2017)

Based on a review of the literature, four factors representative of compact green cities were considered, taking into account cities as complex socio-ecological systems: (1) natural and built environment; (2) multifunctionality; (3) government; and (4) governance. These factors are conceptualized in Table 1:

Table 1 - Factors representative of compact green cities

1. Environment Reflection of built and natural environments	**2. Multifunctionality of uses and focus on social, economic, and ecological aspects**	**3. Government Coordination, leadership, and removal of legal barriers**	**4. Governance Transdisciplinary approach and involvement of local agents**
1.1 Attractiveness and quality: o The attractiveness of housing must be ensured by the quality of the built environment and green spaces o Revitalization of urban centers considering esthetics, infrastructure, pedestrian streets, etc o High-quality green infrastructure compensates for its low quantity	2.1 Social aspects: o Provision of jobs o Supply of diversified housing with affordable prices o Sense of community o Impacts of green areas on health and well-being o Fair access to green spaces/ control of speculation in regions provided with green areas	3.1 Strategic management: o Understand the heterogeneity and complexity of urban ecosystems o Strategies to deal with goals such as densification, quality of life, ecosystems, etc. o Cooperation between sectors of the administration o Overcoming institutional barriers	4.1 Density and integration The individual will of residents, the actions of NGOs, and consultation with researchers can influence urban sprawl and the implementation of green infrastructure. ○
1.2 Integration of density and green infrastructure: o Correlation between types of high-density morphology with the absence of green spaces o Functional or physical integration between green spaces and gray infrastructure (Figure 15)	2.2 Economic aspects: o Economic benefits of compact cities: reduction in per capita infrastructure costs o Economic benefits of green cities: attraction of new businesses ○	3.2 Reflective management: o Analysis of the state of the landscape and the potential impact of urban planning o Monitoring and optimization of existing infrastructure	4.2 Attractiveness and quality: Entrepreneurs, the public, NGOs, and researchers also have a role in providing quality infrastructure (gray and green).
1.3 Concentration and connectivity: o Sustainable growth should achieve high concentrations of commercial, residential, industrial, and transportation areas o This concentration should result in the homogeneous distribution of green spaces	2.3 Ecological aspects: o Ecosystem services provide support for urban planning to reflect the complex ecological impacts of green and compact cities o Mitigation of climate change, stormwater management, food supply (urban garden)	3.3 Multi-scale management: o Cooperation between management at different scales o Consider not only the well-being of residents but also regional interests o Think about the local impact of green areas, and maximize the effects with large-scale green networks	
1.4 Proximity: Distance between different types of land use and related activities within an urban area Short distances between green areas and residences maximize the benefits of an urban green ecosystem.			

Source: Adapted from Artmann et al., (2017)

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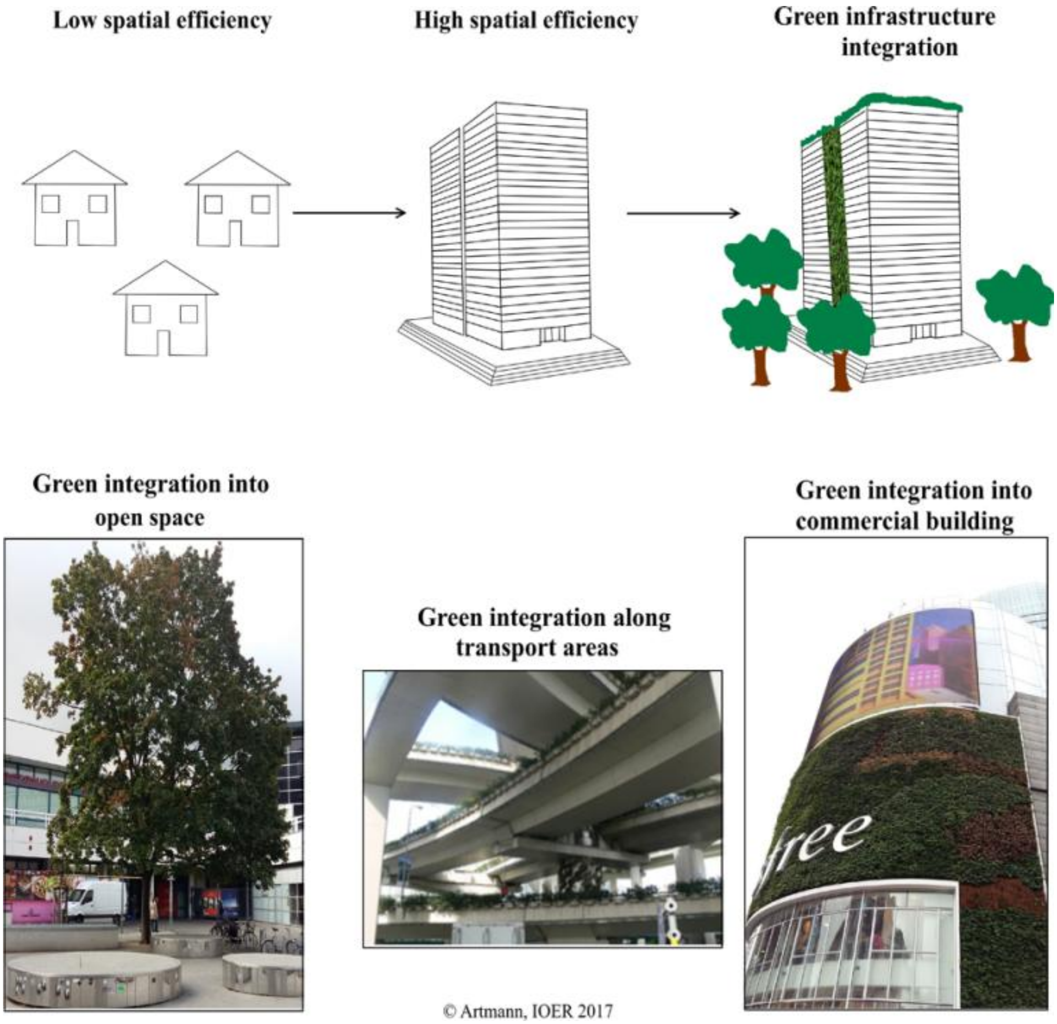
Figure 15–Scheme and examples of smart density and infrastructure integration.



Source: Artmann *et al*., (2017)

Examples of possible indicators for a smart environment of compact and green cities, their criteria, and related monitoring show that a combination of additional methods, particularlly small-scale data sources are needed to comprehensively capture all factors. Thus, in addition to GIS analysis making the density of gray infrastructure visible and mapping small-scale green roofs, a survey of residents to assess access to different patterns of built sites or new technologies should be applied through the smart-compact-green city framework.

In the compact green city approach, the application of the systemic conceptual framework provides indicators for monitoring and land use and for evaluating and supporting urban development strategies, seeking to achieve a balance between compactness and green infrastructure. Some of these indicators are presented in Table 2.

Table 2 - Examples of indicators and their monitoring for a smart, compact, and green environment.

Smart environment of green cities			
FACTOR	**INDICATOR**	**CRITERION (Unit)**	**MONITORING**
Smart integration of green infrastructure	Greening of commercial and industrial areas	Ratio of green flat roofs to non-green roofs in a commercial/industrial area (%)	Mapping of land use and land cover on a scale
	Greening of residential areas	Relação entre telhado plano esverdeado e telhado plano não esverdeado em uma área residencial (%) Ratio of green flat roofs to non-green flat roofs in a residential area (%)	Mapeamento do uso e cobertura da terra em escala Mapping land use and land cover at scale
Smart quality of green infrastructure	Green quality of urban green spaces at the local level	Green volume by type of urban vegetation structure (m3/m2)	Mapping of urban biotope types, analysis of terrestrial and aerial photographs
	Green quality of urban green spaces at the regional and national levels	Percentage of areas protected for nature conservation and species protection (national parks, nature reserves, protected fauna-flora habitats, bird sanctuaries) based on administrative area (%)	GIS analysis
Smart proximity of green infrastructure	Proximity to green areas Urban Residential	Percentage of residents with access to green spaces (>1 ha) within 300 m (%)	GIS analysis
	Proximity to urban parks	Percentage of residents with pedestrian accessibility to urban parks within a certain distance via actual routes (%)	GIS analysis
Smart built environment of compact cities			
FACTOR	**INDICATOR**	**CRITERION (Unit)**	**MONITORING**
Smart density of Gray Infrastructure	Commercial and industrial areas with space efficiency	Residential areas per capita (m2/resident)	GIS analysis
	Residential areas with space efficiency	Residential areas per capita (m2/resident)	GIS analysis
Smart attractiveness of gray infrastructure	Smart attractiveness of commercial areas	Number of cell phone calls in a specific commercial area (dimensionless value)	Mapping of digital footprints
	Smart attractiveness of residential areas	Residents' perception (dimensionless value)	Web search on functional possibilities, social life, appearance of the environment, atmosphere
Smart proximity of gray infrastructure	Smart proximity of commercial and industrial areas	Self-reported walking correlated with access to different types of commercial destinations (dimensionless value)	Research, GIS analysis
	Smart proximity of public transportation	Rail network density of habitable areas (km/km2)	GIS analysis

Source: Adapted from Artmann et al., (2017)

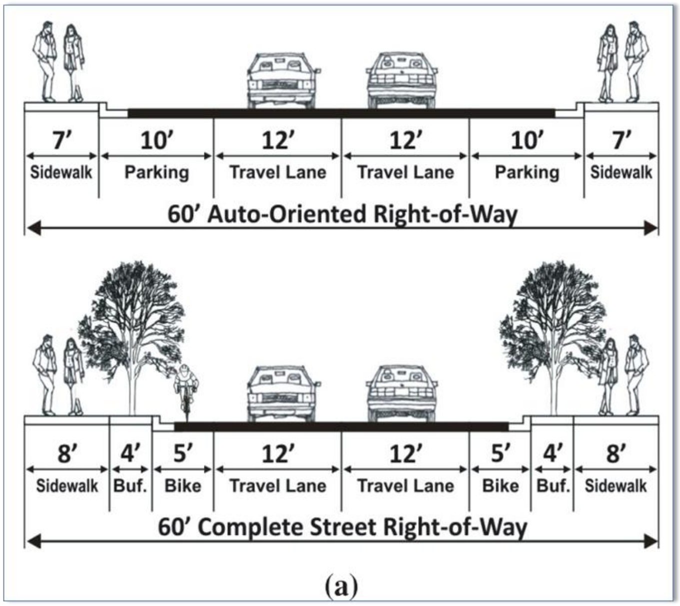
The authors suggest assigning a score to these factors, which will be added if the factor is included in the green and compact city development policies. Adding up the scores obtained, it becomes clear to what extent a balance has been achieved between the proposed city goals.

Three factors were identified that have the greatest potential to negatively affect the application of the proposed conceptual framework, namely: limitations in research and knowledge; unequal access to technological resource data; and conflicts over land use.

4.2 Measuring the completeness of complete streets (HUI et al., 2018)

The authors define complete streets (Figure 16) as streets that safely accommodate all types of users and recognize that a street's functionality is associated with fulfilling three demands or functions: movement (ease of mobility), environment (reduction of environmental impact), and place (social and recreational purpose). Completeness therefore refers to the fulfillment of these three demands.

Figure 16– Cross-section of the segments of the current vs. projected state.



Source: Elias (2011)

Most quantitative assessments of movement function are based on calculating the level of service (LOS) for different modes. The quality of vehicle movement is defined by comparing the operating conditions in the best-case scenario with those in the current scenario. The higher the LOS value for a street, the closer it is to operating under ideal conditions. However, when it comes to non-vehicular transportation, movement quality is impacted not only by LOS, but also user comfort and perception of safety also play a role.

There are several methodologies for determining LOS for vehicles, pedestrians, and cyclists. However, for application on complete streets, there is still no consensus on the best methodology, or even on which factors should be incorporated into the methodologies for service levels of different modes.

In this context, the authors present studies demonstrating that a LOS model is considered adequate for multimodal transportation scenarios when its performance meets expectations, and is appropriate for the application, and it is calibrated to accurately reflect user satisfaction. Since there are many LOS models, the sensitivity of these models must be tested for alternative priority configurations in order to assess whether a given model is sufficiently versatile to produce the expected results.

Another objective of complete streets projects is to increase road safety for all users. However, current methods of quantifying safety, such as collision frequency, cannot identify the specific causes of accidents and are therefore ineffective in suggesting solutions.

Many of the potential environmental impacts present on a street can be measured and modeled for an existing street, or predicted in the proposed design of a new street. However, this is not commonly done in the context of complete streets.

The difficulty lies in determining which environmental impacts should be quantified in a complete street project, since not all are sufficiently important or sensitive to be measured or modeled in different street designs. Therefore, the following aspects should be considered when determining which environmental impact will be analyzed: its importance when compared to other types of environmental impacts; the scale of the impact when compared to the scale of the street; the acceptable or desirable levels of impact on the street.

The street is considered as a destination, rather than a means of getting from one place to another. Thus, designing a complete street that meets the demands of the location requires an understanding of the relationships between the street and the adjacent buildings and spaces.

The authors state that there are still no proposed methods for quantifying the fulfillment of the function of place. Some potential substitute methods of quantification include measuring economic impacts on the street and measuring the health and well-being of the community. Although they are not able to fully capture the nuance of the function of place, these methods have proven useful in assessing the impacts of complete street projects.

Alternatively, complete streets can be evaluated as places using indices developed for urban domain evaluation. However, since these indices were not developed for street evaluation, they include several elements not present in the scope of complete street projects.

There are several ways to measure the performance of a street, but not all are suitable for the complete streets design process. The main challenges encountered in the quantitative assessment of each function are presented in Table 3.

Table 3 - Challenges for quantitative assessment in fulfilling the functions of movement, environment, and place

Motion function	Environmental function	Place function
o Determination of which of the many available models to use o Requires a sensitivity analysis of the models to determine which is sufficiently sensitive to street elements	o Determination of which of the many available models to use o Determine which of the impacts are most prominent at the street level	o Absence of existing quantitative models o Substitute models do not fully capture the nuance of the place or present elements that are not relevant to the street evaluation

Source: Adapted from HUI et. al., (2018).

Despite the abundance of methods for quantifying a street's ability to serve different functions, an additional challenge arises in the difficulty of interpreting and combining the different metrics in order to reflect their relative importance on a given street. In addition, the function of each street must be taken into account when determining its expected performance. Thus, a context-sensitive approach is necessary when evaluating complete streets (Urban Exposome, Andrianou et al., 2019; Andrianou & Makris, 2018).

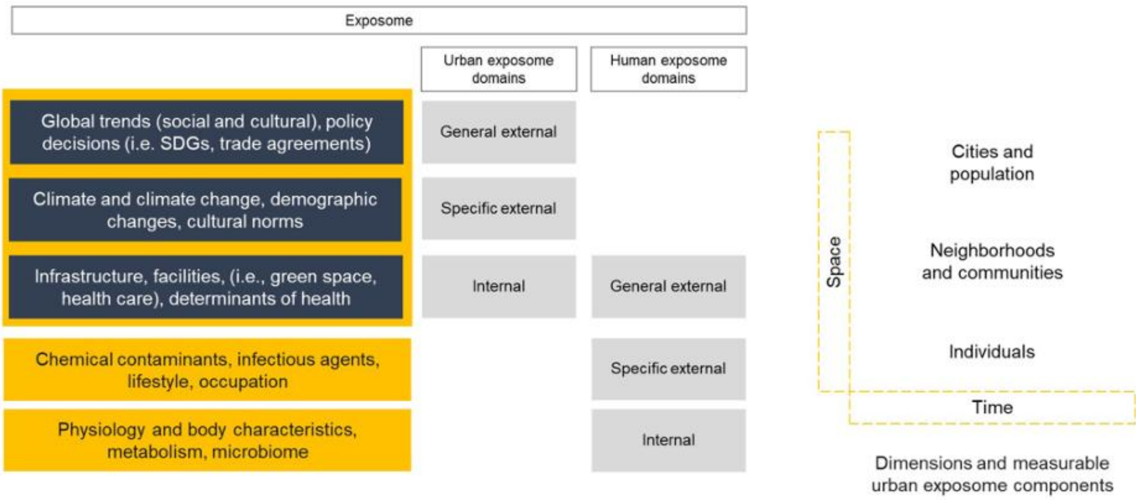
In the context of global efforts focused on urban health issues, the authors draw on the relatively new concept of the human exposome, i.e., the totality of exposures throughout life that has recently emerged in the field of environmental health sciences. This term can be defined as: “the continuous temporal and spatial surveillance/monitoring of quantitative and qualitative indicators associated with external and internal urban parameters (belonging to the domains of the urban exposome) that would ultimately shape the quality of life and health of the urban population, using small areas of the city, such as neighborhoods, smaller administrative districts, as a reference point.” The authors believe this concept could provide us with the theoretical framework for visualizing and evaluating urban life by combining “domains” that can be used alongside those used for the human exposome (ANDRIANOU et al., 2019).

The human exposome is a dynamic entity divided into three main domains, namely, general and specific external and the internal domain, keeping the individual as the point of reference. It can be seen as the sum of exposures related to life in the city (Figure 18). However, this definition does not take into account how cities and their environments are shaped (by populations, infrastructures, and services) and how they evolve spatio-temporally. Thus, speaking in terms of exposure and maintaining 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 dynamic equilibrium and comprise independent units that constantly interact with the city's residents.

For example, the infrastructure system includes units ranging from water/effluent/gas distribution systems, transportation to green spaces, while, in another case, the units of the governance system are the different institutions that develop and guide policies in the city. These systems are all modeled and managed at various scales of the urban locality, from the neighborhood level to the community, municipal, and city-wide levels.

Therefore, the concept of "urban exposome" could provide us with the theoretical framework for visualizing and evaluating urban life, combining urban domains to be used in parallel with those used for the human exposome (Figure 17).

Figure 17 – The continuum of the urban exposome - human exposome. Neighborhoods and individuals, cities and populations are the measurable components of urban and human exposomes, integrating assessments at the local (urban) and personal levels.



Source: Adrianou e Makris (2018)

5 APPLICATIONS AND EXAMPLES OF GOOD PRACTICES

5.1 Rose Fitzgerald Kennedy Greenway Linear Park (Horte and Eisenman, 2020)

The Rose Fitzgerald Kennedy Greenway, or simply Greenway, is located in the central region of the city of Boston, Massachusetts, beginning in the North End, passing through the Waterfront, and ending in Chinatown (Figures 18 and 19). In 1991, construction began on tunnels to improve and expand the road network in downtown Boston. As a result, the John F. Kennedy overpass became obsolete, as all traffic would go through the tunnels. Thus, the city's civil organizations saw an opportunity to create another green space. It took more than 17 years of discussions and projects before Rose Fitzgerald Kennedy was finally opened in 2008. The park is 2.4 km long, with an area of approximately 61,000 m².

Figure 18– - Location of the Greenway, Downtown Boston – USA.

Source: Boston Planning & Development Agency (s.d.).

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Figura 19– - Figure 19 - Implementation of Greenway Park before and after.

Fonte: Horte e Eisenman (2020)

5.2 Complete streets – Visconde do Rio Branco Avenue – PMN/RJ (n.d.)

In 2017, the Complete Streets project was developed for Avenida Visconde do Rio Branco, in Niterói, Rio de Janeiro, in partnership with WRI BRASIL (World Resources Institute). The urban redevelopment aims to redistribute the circulation space for different modes of transport (Figure 20). The location was chosen because it is a primary arterial road with a maximum speed limit of 40 km/h, used by motor vehicles, bicycles, and pedestrians, with mixed land use, primarily for commerce and services. In addition, it is noteworthy for its waterfront location, with access to tourist attractions such as Caminho Niemeyer and São Sebastião Fish Market.

The project included diagnostic phases, identification of the actors involved (public and private agents), alignment with local commerce, questionnaires, and field research. The inclusion of the concept of complete streets provides benefits that go beyond mobility, but also include safety, health, and equality (NITEROI, [n.d.]).

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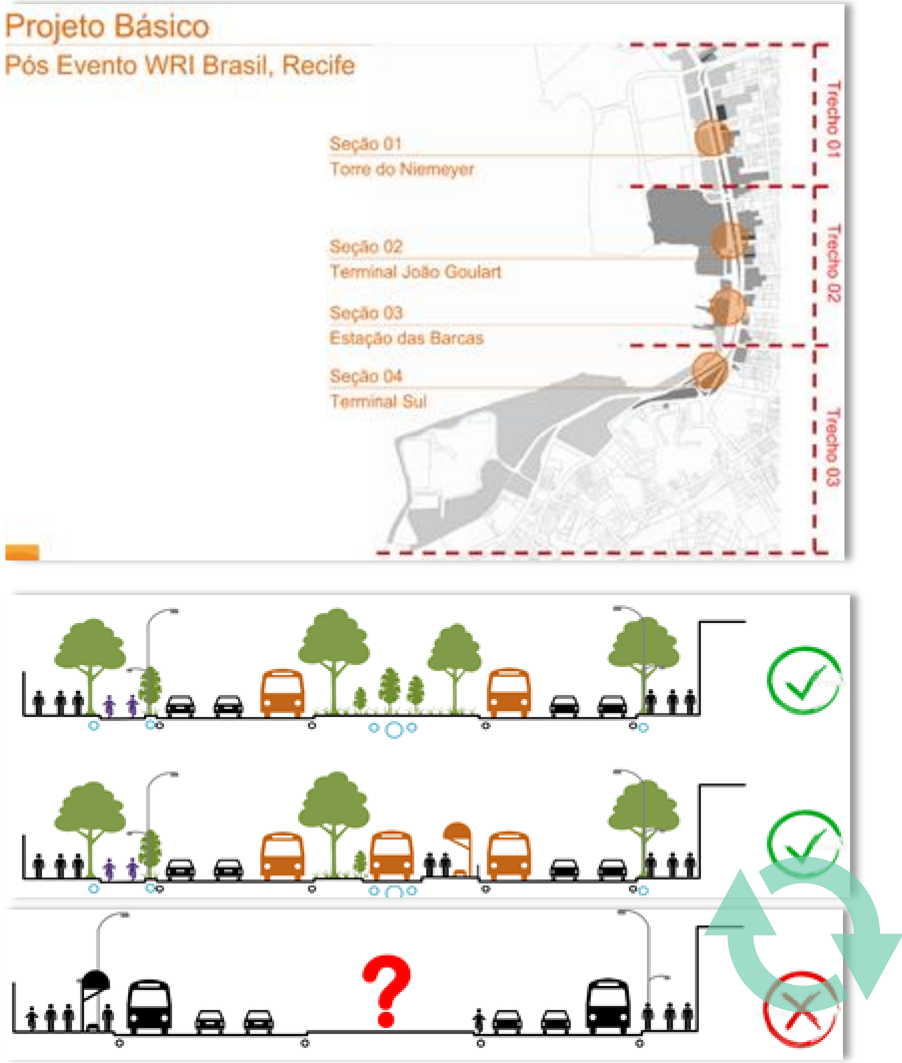
Figure 20 - Visconde do Rio Branco – Niterói/RJ.



Source: Niterói Citty Hall (htt0://www.niteroi.rj.gov.br/pmus/downloads/Ruas_Completas.pdf)

5.3 Urban exposome – practical application of the urban exposome framework in the urban environment of Limassol, Cyprus – Andrianou et al. (2019)

The parts of the urban exposome specifically discussed in the current analysis include a study of perceptions and a study of the urban population, which includes parameters measured in drinking water to assess water quality, along with responses to questionnaires on individual lifestyle, behavior, and personal health indicators.

In this study, water quality parameters were mapped and questionnaires were administered to the population. Subsequently, an association analysis was performed using the variables obtained to describe correlations between them (Figure 21). This analysis uses a new interdisciplinary approach to apply the urban exposome framework with a focus on drinking water and quality of life indicators. This type of study of the city and its smaller areas (blocks)

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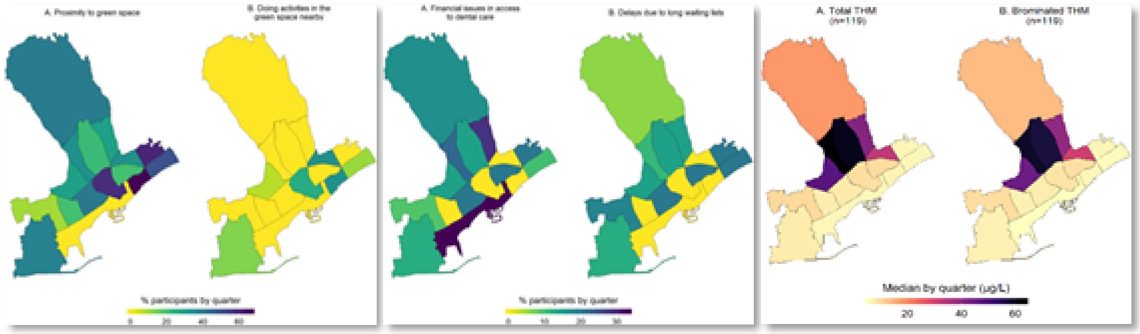
can be adapted to contribute to the improvement of urban life and assist in decision-making on the effects of urban planning on urban health (Andrianou et al., 2019).

Figure 21– Urban exposome maps in Cyprus



Maps showing the percentage of study participants in neighborhoods in the municipality of Limassol, Cyprus, who agree that they live close to green space (A) and engage in activities in nearby green space (B).	Percentage of participants who report restrictions in access to healthcare, i.e., financial issues in accessing dental care (A) and delays due to long waiting lists (B).	Maps of median total levels of THM (A) and BrTHM (B) by neighborhood in the municipality of Limassol, Cyprus, in 2017.

Source: Andrianou *et al*. (2019)

Based on the examples of public health practices, a summary table was created with the three approaches discussed in this paper, the benefits of each for public health, the methodology of the study, and examples of application (Table 4).

Table 4 - Summary table of good urban and environmental planning practices discussed in this paper.

GOOD PRACTICES IN URBAN AND ENVIRONMENTAL PLANNING	**HEALTH BENEFITS**	**METHODOLOGIES FOR STUDY**	**EXAMPLES OF APPLICATION**
GREEN INFRASTRUCTURE	o Improvement of air quality; o Urban water management (control of floods, inundations, etc.); o Mitigation of heat islands; o Mental health and social security; o Leisure spaces.	o Conceptual framework for compact and green cities (ARTMANN et al., 2017); o Objective: Balance aspects related to compactness and green areas	Linear Park – Greenway - Boston 

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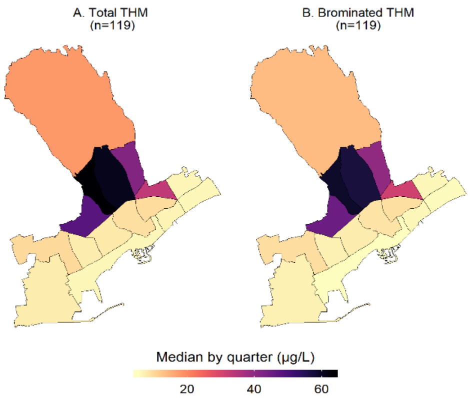
COMPLETE STREETS	o Walkable distances promote lower obesity rates and encourage physical activity.	o Measuring the completeness of streets (HUI et al., 2018); o Objective: To meet the demands of streets according to their functions of movement, environment, and place.	Rio Branco Avenue – Niterói (project) 
URBAN EXPOSOME	o Monitorar a dinâmica da saúde urbana com uma análise descritiva, por exemplo, de parâmetros químicos e microbiológicos da qualidade da água potável, juntamente com indicadores de qualidade de vida, pesquisa de percepção de autoridades e população o Monitoring urban health dynamics with a descriptive analysis, for example, of chemical and microbiological parameters of drinking water quality, together with quality of life indicators, perception surveys of authorities, and the population	o Application of the urban exposome framework using drinking water and quality of life indicators: a proof-of-concept study in Limassol, Cyprus (Andrianou et al., 2019); o Objective: To analyze the concept of urban exposome by applying the method in a city in Cyprus.	Water quality – Limassol – Cyprus 

Source: Own elaboration (2021)

6 CONCLUSIONS

Given the growing urban population, climate change, and disorderly urbanization models, which historically demand unsustainable urban infrastructure, a "new paradigm" challenges urban and environmental planning: concern for the health of the urban population. It is no surprise that the recent COVID-19 pandemic has generated so much uncertainty, as it strikes at the heart of the urban world. In fact, since the plague of Athens, reported by Thucydides, "the emergence/proliferation of diseases in cities (Black Death, cholera, typhoid fever, Spanish flu, etc.) is nothing new and did not represent the end of cities." Many of these diseases were related to drinking water and sewage systems and led to changes in these systems that allowed cities to thrive and expand. The recent pandemic will certainly bring new paradigms in relation to the planning and implementation of urban infrastructure, notably road and basic sanitation systems, the former seeking alternatives to mass transportation (which induces virus transmission) and the latter due to its essential role in preventing transmission.

Developing this work, we revisited some concepts related to urban infrastructure and its relationship with sanitation and health. Thus, factors such as urban form, settlement patterns, population density, and urban social practices are interrelated, influencing the expansion of the cities and leading to the emergence of diseases.

In this context, good urban and environmental planning practices have attracted significant attention from planners and public policymakers. Green infrastructure and complete streets are examples of these good practices and are addressed with new methodologies, such as the adoption of indicators that reflect the balance between gray and green/blue infrastructure in compact cities. The adoption of GIS-based tools is essential for this purpose. Regarding complete streets, an approach is presented that goes beyond the safe accommodation of all types of users in these spaces, but also recognizes that the functionality of a street is associated with the fulfillment of three demands, or three functions: movement (ease of mobility), environment (reduction of environmental impact), and place (the street has a social and recreational purpose).

In addition, the new concept of urban exposome was explored, which consists of the spatiotemporal monitoring of environmental, social, infrastructure, and health indicators and parameters of a given population. Finally, examples of the application and projects of these good practices were presented, allowing the identification of the potential and functionality of these approaches as sustainable alternatives for urban and environmental planning.

Despite the theoretical and methodological nature of the study, it is recommended that future research be conducted using an empirical approach, through field analyses in Brazilian cities, to test the local applicability of the proposed methodologies. This would allow the suggested indicators to be validated and the monitoring criteria adapted to specific urban contexts. Additionally, this study highlights the potential of systematization as a tool to support the decision-making processes of technicians, public managers, and urban planners, contributing to the formulation of more integrated and sustainable policies.

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DECLARATIONS

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We, Flávio Souza Azevedo; Paula Isabella de O. Rocha; José Augusto Ribeiro da Silveira; Celso Augusto Guimarães Santos; Richarde Marques da Silva; Edson Leite Ribeiro; Juliana Xavier Andrade Oliveira; Larissa Ellen Oliveira de Lima, declaramos que o manuscrito intitulado "**Urban Management and Health: New Methodologies for old challenges**":

1. **Financial ties**: Does not have financial ties that could influence the results or interpretation of the work
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