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Artigo

MUSINGS ON NEUROURBANISM, PUBLIC SPACE AND URBAN HEALTH

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ABSTRACT – The recent pandemic outbreak warned of the urgent need for closer interaction between health and spatial planning. The relationship between urban space and health has been widely proven and led to the emergence of new concepts, such as neurourbanism, an interdisciplinary field of research that aims to explain the relationship between mental health and the well-being of city life. The embryonic state of these interdisciplinary research fields requires further contributions to their consolidation and guidelines for practitioners and policymakers. The main aim of this article is to contribute to the discussion through reflections on public spaces and urban health. A critical analysis was conducted to respond to the following specific objectives: 1) to highlight the importance of public space for the promotion of quality of life; 2) to reinforce the awareness that the urban environment affects mental health and well-being; 3) to propose an organisation of health impact factors (determinants of urban health) that works as a tool for objective health assessment and monitoring in cities and; 4) to reinforce work on the importance of neurourbanism as an interdisciplinary science that unites neuroscience and urban planning. Despite the empiri-

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cal association between health (physical and mental) and the built environment recently demonstrated Covid-19 pandemic, scarce research and evidence-based recommendations have been produced towards healthier cities.

Keywords: Neurourbanism; urban space; city; urban health; mental health.

RESUMO – REFLEXÕES SOBRE NEUROURBANISMO, ESPAÇO PÚBLICO E SAÚDE URBANA. A recente pandemia alertou para a necessidade urgente de uma interação mais estreita entre a saúde e o ordenamento do território. A relação entre o espaço urbano e a saúde tem sido amplamente comprovada e levou ao aparecimento de novos conceitos, como o neurourbanismo, um campo de investigação interdisciplinar que pretende explicar a relação entre a saúde mental e o bem-estar da vida na cidade. O estado embrionário destes campos de investigação interdisciplinares requer mais contributos para a sua consolidação e orientações para os profissionais e decisores políticos. O principal objetivo deste artigo é contribuir para a discussão através de reflexões sobre espaços públicos e saúde urbana. Foi realizada uma análise crítica para responder aos seguintes objetivos específicos 1) destacar a importância do espaço público para a promoção da qualidade de vida; 2) reforçar a consciência de que o ambiente urbano afeta a saúde mental e o bem-estar; 3) propor uma organização dos fatores de impacto na saúde (determinantes da saúde urbana) que funcione como ferramenta de avaliação e monitoramento objetivo da saúde nas cidades e; 4) reforçar o trabalho sobre a importância do neurourbanismo como ciência interdisciplinar que une neurociência e planejamento urbano. Apesar da associação empírica entre a saúde (física e mental) e o ambiente construído, recentemente demonstrada pela pandemia de Covid-19, tem sido escassa a investigação e as recomendações baseadas em evidências para cidades mais saudáveis.

Palavras-chave: Neurourbanismo; espaço urbano; cidade; saúde urbana; saúde mental.

RÉSUMÉ – RÉFLEXIONS SUR LE NEUROURBANISME, L'ESPACE PUBLIC ET LA SANTÉ URBAINE. La récente pandémie a mis en évidence le besoin urgent d'une interaction plus étroite entre la santé et l'aménagement du territoire. La relation entre l'espace urbain et la santé a été largement prouvée et a conduit à l'émergence de nouveaux concepts, tels que le neurorbanisme, un champ de recherche interdisciplinaire qui vise à expliquer la relation entre la santé mentale et le bien-être de la vie urbaine. L'état embryonnaire de ces champs de recherche interdisciplinaires exige de nouvelles contributions à leur consolidation et à l'élaboration de lignes directrices pour les praticiens et les décideurs politiques. L'objectif principal de cet article est de contribuer à la discussion par des réflexions sur les espaces publics et la santé urbaine. Une analyse critique a été menée pour répondre aux objectifs spécifiques suivants: 1) souligner l'importance de l'espace public pour la promotion de la qualité de vie; 2) renforcer la prise de conscience que l'environnement urbain affecte la santé mentale et le bien-être; 3) proposer une organisation des facteurs d'impact sur la santé (déterminants de la santé urbaine) qui fonctionne comme un outil d'évaluation et de surveillance objective de la santé dans les villes et; 4) renforcer le travail sur l'importance du neurourbanisme en tant que science interdisciplinaire qui unit les neurosciences et la planification urbaine. Malgré l'association empirique entre la santé (physique et mentale) et l'environnement bâti récemment démontrée par la pandémie de Covid-19, peu de recherches et de recommandations fondées sur des données probantes ont été produites en vue de rendre les villes plus saines.

Mots clés: Neurourbanisme; espace urbain; ville; santé urbaine; santé mentale.

RESUMEN – REFLEXIONES SOBRE NEUROURBANISMO, ESPACIO PÚBLICO Y SALUD URBANA. La reciente pandemia alertó de la urgente necesidad de una interacción más estrecha entre salud y ordenación del territorio. La relación entre el espacio urbano y la salud ha quedado ampliamente demostrada y ha propiciado la aparición de nuevos conceptos, como el neurourbanismo, un campo de investigación interdisciplinar que pretende explicar la relación entre la salud mental y el bienestar de la vida en la ciudad. El estado embrionario de estos campos interdisciplinarios de investigación requiere nuevas contribuciones para su consolidación y directrices para profesionales y responsables políticos. El objetivo principal de este artículo es contribuir al debate mediante reflexiones sobre los espacios públicos y la salud urbana. Se ha realizado un análisis crítico para responder a los siguientes objetivos específicos 1) resaltar la importancia del espacio público para la promoción de la calidad de vida; 2) reforzar la conciencia de que el entorno urbano afecta a la salud mental y al bienestar; 3) proponer una organización de los factores de impacto en la salud (determinantes de la salud urbana) que funcione como herramienta para la evaluación y monitorización objetiva de la salud en las ciudades y; 4) reforzar los trabajos sobre la importancia del neurourbanismo como ciencia interdisciplinar que une neurociencia y urbanismo. A pesar de la asociación empírica entre la salud (física y mental) y el entorno construido demostrada recientemente Covid-19 pandemia, se han producido escasas investigaciones y recomendaciones basadas en pruebas hacia ciudades más saludables.

Palavras clave: Neurourbanismo; espacio urbano; ciudad; salud urbana; salud mental.

I. INTRODUCTION

The link between urban development and well-being, happiness, and quality of life, between physical space and health, between the city and public space and the advantages and disadvantages of their use, is an old discussion that has gained new momentum in the last three decades, by the exponential increase of urban problems and the need to with them. Urban planners and policymakers show haste to implement a myriad of actions for requalification and environmental valorisation, urban rehabilitation, revitalisation and regenerative public spaces, integrated strategies and processes for the reconciliation between people and places, increase places connectivity, promote compactness, fight sprawl, improve urban green areas and integrate nature in cities, upgrade waterfronts and soft transport modes (cycling and walking) to fight car use and private transport, among other initiatives.

While this urban development aimed to cope with urban problems and meet the needs of its citizens, leverage the quality of life, and promote health and well-being, there is "grey" literature highlighting the pros and cons of the urban environment and urban living style. Indeed, urban development outcomes have proven to be positive, fostering people's general well-being and quality of life, but also harmful by affecting people's health and well-being (European Commission [EC] *et al.*, 2019), significantly burdening states' finances and impacting the public economy. Then, to reduce uncertainty within urban development outcomes, there is an urgent need to build evidence on how and how much

the urban environment people live in work, and spend time in, affects their health and well-being. Although the challenge has been stressed through the years, there is insufficient research to provide evidence-based knowledge.

Moreover, according to the United Nations (UN) population prospects, not only world population is increasing at an astonishing rate, but the urban population is projected to increase at an even higher rate. Indeed, the number of urban dwellers has been progressively increasing and, already in 2022, the UN reiterates that "six out of every ten people in the world are expected to reside in urban areas by 2030, rising to 83% by 2050." (United Nations Human Settlements Programme [UN-Habitat], 2022, p. 9).

Therefore, it is impossible to dissociate the dynamics of world population growth from emerging phenomena and challenges such as climate change and climate action, the continued use and consumption of fossil fuels, the necessary decarbonisation of the planet, geopolitical issues and their impacts on human life, people's health, and its socio-cultural dimension.

Taking mental health as a component of health that was (especially before the pandemic) often less considered, the existing knowledge is mainly empirical through a few studies correlating urban design with health issues and health benefits. However, there is still no evidence that mental health concerns are considered in the current urban planning processes/methodologies. One of the positive side effects of the pandemic is that it drew people's attention to important issues, such as the mental health effects of the built environment, that until now were not correctly recognised. Another relevant issue raised through the pandemic was the importance of scientific knowledge for policymakers to support decisions. The 'scientification' of public policies during pandemic outbreaks was highly reported and impacted collective awareness of the importance of science with societal impact. In the scope of this scientific chain value, the need to have metrics for evaluation and benchmarking was stressed in different forums involving academics and politicians. In this realm, urban health determinants to measure, evaluate and classify the impact of urban space on the mental health of citizens were at the core of the discussion worldwide.

In this context, geography plays a key role, as many parameters mentioned in the literature are geographical-based, e.g. landscape (land use and land cover, topography, accessibility, connectivity, diversity, buildings, houses, etc.), the socio-economic structure of the population (age, gender, purchase power, education, etc.), the configuration of urban space, the cultural heritage, the climate and environmental factors (air quality, noise, temperature, relative humidity, wind, etc.), the health indicators (people diagnosed with a specific type of diseases; a daily dose of medication; access to health care facilities), and lifestyle indicators (drugs and alcohol consumption indicators, sports activity, etc.); the territory overall organisation (facilities, infrastructures, mobility, etc.), among others, that have a direct either-or indirect influence on people's health and mental well-being.

The analysis of physical space and its relationship with health has a long history in architecture, interiors, work, and residence spaces (Higuera-Trujillo *et al*., 2021). However, research on the relationship between human health and the urban built environment is still at an early stage. In 'Neurourbanism: towards a new discipline' (Adli *et al*., 2017), the lack

of close and effective interaction between urban planners and health professionals is evident, considering several studies that point to the increase in mental disorders such as anxiety, stress, depression, and other emotional disorders in urban environments (Peen *et al.*, 2010). Thus, it is considered that neurourbanism is a new field that explores the neuroscience and the biological underpinnings of mental states and disorders to ensure a better quality of life in urban areas (Ancora *et al.*, 2022; McCay *et al.*, 2017; Pykett *et al.*, 2020).

Even before the pandemic, several global institutions identified the need to study the urban context and the quality of life (also from the perspective of individual health), of which the UN and the European Union (EU) stand out. The UN-Habitat and the World Health Organization (WHO) have demonstrated that mental health has been at the heart of their policy research and work for several decades (WHO, 1998, 2001, 2010). Moreover, more recently, the EU, in its strategic investment fighting against imbalances and inequities, launched programmes and funding lines dedicated to promoting health in cities. As an example of such funding policies to foster research on the topic, we can highlight the eMOTIONAL project Cities, a research & innovation actions (RIA) project supported by the EU Horizon 2020 programme. Under this call, the European Commission (EC) supports five more projects worth 30 million euros total, which, together, constitute the Urban Health Cluster (UHC), the first European cluster to improve and safeguard the health and well-being of citizens, leaving none behind. Promoting and maintaining mental health and well-being and reducing mental illness risk factors are pivotal to achieving urban sustainability and building healthier, resilient, and human-centred cities and communities.

This article attempts to raise awareness of the importance of urban planning and urban design as a technical and political tool for preparedness for the emergent challenges cities and Humanity face and to guarantee people's mental health and well-being. The article is organised in four parts. The first part discusses on public spaces realm of public health and summarises its conceptual evolution, drawing on the findings on the relations between the built environment and health, and more specifically, mental health; the second part of this article is dedicated to discussing the concept of urban health, mental health and urban stressors to shed light on the impact of an urbanite in people's health and well-being; the third part is divided on the discussion of the determinants of urban health based on the extensive narrative on the topic, and ends with a summarised table of the built environments determinants and its adverse impacts on mental health; the fourth and last part it is dedicated to final remarks.

II. PUBLIC SPACE AS THE COLLECTIVE LIVING ROOM

The history of a city is the history of its public space (Borja & Muxi, 2003) because it is where all social and political activities are printed and the place of all discussions and decisions that affect the collective. In this regard, public spaces demand thinking and design, e.g., the outline, the matter, the form, as well as the banal urban features citizens use daily

for interaction with the environment, to enjoy, or to express themselves through social and artistic manifestations or simply the most careless use of crossing and permanence.

The understanding of the 'public space' concept varies. There are those who understand it as a set of voids, as a space that mediates volumes, as small 'leftovers' that must be filled up, and others who do not understand them and therefore do not place them at the forefront of planning and making cities. However, public space is the place that promotes socialisation and, as such, is a fundamental space to combat social isolation and the mental health problems that often result from it. Public spaces encompass publicly owned or designated for public use, where everyone can freely access and enjoy them without making a profit (UN-HABITAT, 2016).

In the scope of this article, public places are considered to be the most visible, collective, accessible and common spaces of the city. This vision of public space has gained increased importance in recent decades, and it is also the one that contributes to the satisfaction of different quality of life criteria, even when the "death" of public space, according to Remesar, has been announced. Despite this, municipalities persist in investing in public space as an area constantly expanding, resulting from changes in mobility and transportation infrastructures. The design and maintenance of streets have become a significant challenge for local authorities, who must find ways to harness the symbolic power of public spaces, as they have always done.

In the late 1960s of the 20th century, Jan Gehl "transformed" Copenhagen into a "laboratory city" for several studies on the interaction between public space and public life, intending to understand this interaction, testing different methods and analysing the resulting patterns. More recently, the Gehl Institute and the Robert Wood Johnson Foundation have developed an 'Inclusive Healthy Places (IHP) Framework' (Gardner *et al.*, 2018) as a data-driven tool dedicated to people in the assumption of bridging health equity gaps in public space. Understanding Community Context; Support Inclusion in Process; Design and Program Public Space for Health Equity; and Foster Social Resilience are the four principles for creating healthy and inclusive places.

Another example that underlines the importance of the public space regarding its impact on general well-being is the American 'Project for Public Spaces', started in 1975, as one of the first attempts to systematise what makes a Great Place based on a set and sub-set of principles (fig. 1). The systematisation has a form of a wheel with three layers from the centre to the edge of the wheel, where in the centre there are four main principles-dimensions: 1) sociability, 2) uses and activities, 3) access and connections, and 4) comfort and image, each one of them sub-divided into attributes in a second layer, and finally the third layer with the identification of the parameters, which should guide an urban intervention that comes closer to citizens' needs. The importance of current health promotion through public spaces and outreach relationships has guided the 'Project for Public Spaces' to achieve partnerships with companies and foundations that provide funding, technical assistance, and capacity building to local organisations. In this way, it is possible to ensure that more people have access to public spaces with community power as if they were collective living rooms.

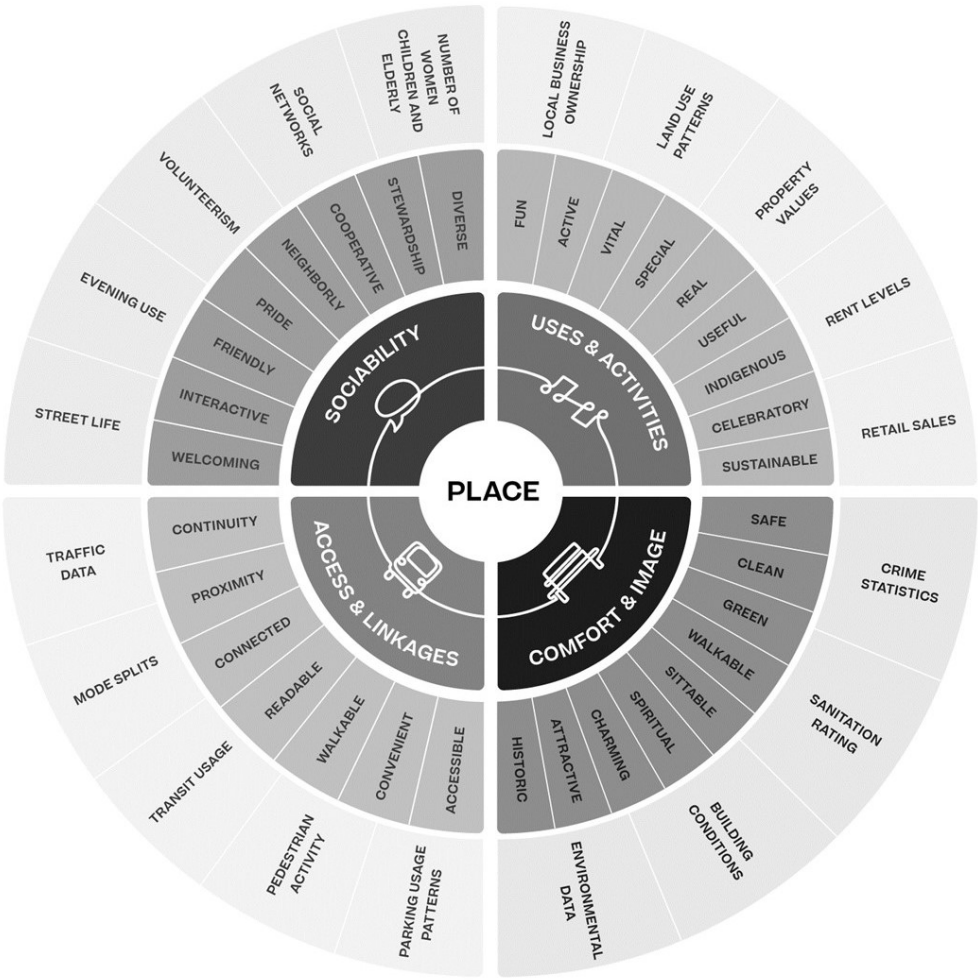

Fig. 1 – What Makes a Great Place?

Fig. 1 – O que é que faz um grande lugar?

Source: Project for Public Spaces, 2020

> Public civic space is not a residual space between streets and buildings. Nor is it an empty space considered public simply for legal reasons. Nor is it a "specialised" space, to which one has to go like someone who goes to a museum or a show. Rather, these spaces are potential public spaces, but something more is needed for them to be public civic spaces. (Borja & Muxi, 2003, p. 15)

Through public space, solutions were tailored to each era's flavours of time, and some of those solutions still inspire many current interventions. Here are some of the cities labels or buzzwords of the epoch: 'Garden' (Howard, 1898), 'Soft' (Raban, 1974), 'Sustain-

able', from the diffusion of the term 'sustainable development' (Keeble, 1988), 'Global' (Sassen, 1991), 'Smart' (Deakin & Al Waer, 2011), 'Innovative', 'Resilient', 'Equitable', the '15 minute' (Moreno *et al.*, 2021) or the five, ten, or twenty-minute cities or 'neighbourhoods', depending on the scales and the means of mobility.

From 'ecocities' (Register, 1987) to 'healthy cities' or 'healthy communities', which, for the first time, puts health and urban design together in the perspective of understanding and mitigating the stress on human health. The WHO 'Healthy Cities and Villages' initiative in 1986 brought the importance of the topic to public health policies. They produced the first international agreement in this context, the Ottawa Charter for Health Promotion, more than 30 years ago, the cornerstone document for public health promotion.

> Public spaces make up between two and 15% of land in city centres in Europe. Both their physical and social functions are essential and can relieve some of the pressures exerted on a city by a growing population. (...) In future cities, we will need to optimise the distribution and use of public space to ensure that it is safe, accessible, and inclusive for all. (EC *et al.*, 2019, p. 92)

III. HEALTH(S): THE HUMAN, THE URBAN AND THE MENTAL

1. Health

It is in the preamble to the Constitution of the World Health Organization – "(…) adopted by the International Health Conference held in New York from 19 June to 22 July 1946, signed on 22 July 1946 by the representatives of 61 States (…), and entered into force on 7 April 1948" – that the notion of 'Health' is defined and comes to the present day, incorporating the revisions that follow.

> The States Parties to this Constitution declare, in conformity with the Charter of the United Nations, that the following principles are basic to the happiness, harmonious relations and security of all peoples: Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. (WHO, 1946, p. 1)

This definition expresses "(...) that there is much more to health than simply a collection of negatives – a state of not suffering from any designated undesirable condition." (Evans & Stoddart, 1990, p. 1347). Several circumstances influence human health: the personal characteristics of each and environmental factors, be they social, economic, or physical. These factors – health determinants – are defined by WHO as "the range of behavioural, biological, socio-economic, and environmental factors which influence the health status of individuals or populations" (WHO, 2021, p. 4).

Whitehead and Dahlgren's 'rainbow model of the determinants of health' has become an iconic illustration of the significant groups of determinants, adopted by WHO and adapted by several authors, referring, from the inside out: 1) age, sex, and hereditary factors; 2) individual lifestyle factors; 3) social and community networks; 4) living and working conditions; and 5) general socio-economic, cultural and environmental condi-

tions (Dahlgren & Whitehead, 1991). The weight represented by each of these determinants is variable and has been the subject of study in recent decades. The Health Mission states that biological and genetic factors and health behaviours affect health up to 25%. In contrast, factors of the social and physical environment and the health service account for 75% (Health Mission, 2017).

In an article that takes as reference the 'County Health Rankings Framework' (Stiefel *et al*., 2020), what is inherent to human conditions is confined to the personal socio-economic context (which represents the importance of 40%) and behaviour (where genetic and acquired issues can be included) which represent 30%; what depends on externalities includes access to healthcare (20%) and the built environment which represents, for this proposal, the shortest slice of this influence (10%).

The concepts of health exist along a *continuum* without distinct boundaries; however, this does not preclude us from acknowledging their distinctions. Various concepts are neither correct nor incorrect; they serve different purposes and have different areas of applicability. Regardless of the level of health definition employed, it is crucial to differentiate it from the issue of determining the factors that contribute to that definition of health (Marmor, 1989).

2. Urban Health

The urban health concept, accordingly, to one of the definitions of WHO's development, includes 'urban governance', 'population characteristics', 'the natural and built environment', 'the social and economic environment', 'food quality' and 'emergency health services and management' as factors contributing positively or negatively to urban health, but also about individual health within the urban context.

> For example, in developing countries, the best urban governance can help produce 75 years or more of life expectancy. With poor urban governance, life expectancy can be as low as 35 years. (…) While most of these root causes lie beyond the direct control of the health sector, local leaders have direct influence over a wide range of urban health determinants, from housing and transport policies to social services, to smoking regulations and the policies that govern food marketing and sales. (WHO, 2010, p. 5)

Therefore, it is critical to identify and reorganise, upfront, the determinants that go beyond human health or the "health of cities" and are not restricted to social ones (social health determinants), on which there has been focusing most of the research on the topic in recent decades. Moreover, it is essential to mention that the proposal of determinants presented here (fig. 3) correlates the built environment with both physical and mental health, as they are inseparable. Indeed, urban health reflects the impact of the physical and social environment on the quality of life and well-being of individuals and communities living in urban areas. The physical and built environment, including urban structures, infrastructure, and spaces, can significantly affect health, mainly when issues such as water quality or air pollution arise. On the other hand, the urban environment can also contribute positively to health through the presence of open, green, and recreational spaces (Michalos, 2014).

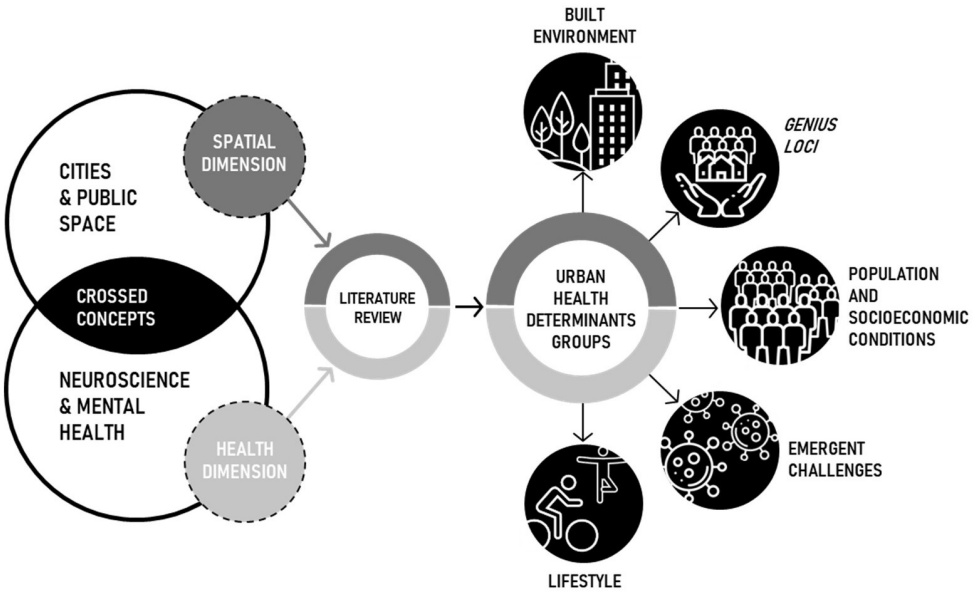

Fig. 2 – A proposal diagram explaining how the five groups of urban health determinants were achieved.

Fig. 2 – Uma proposta de diagrama para explicar como os cinco grupos dos determinantes da saúde urbana foram alcançados.

3. Mental Health

The built environment can influence physical and mental health in both favourable and unfavourable ways, emphasising the significance of purposeful planning and policy initiatives incorporating a health perspective. Mental health is a complex matter with no single cause but is shaped by numerous factors that can affect an individual's mental well-being (Van Winckle *et al.*, 2022). According to the WHO, "Mental health is a state of well-being in which an individual realises his or her own abilities, can cope with the normal stresses of life, can work productively and is able to make a contribution to his or her community" (WHO, 2019, p. 1). In this regard, emphasising the community value, David Sim highlights the role of everyday places and proximity where urban interventions can flesh out social relationships and communities. In David Sim's words, "Neighbourhood is not a place. Neighbourhood is a state of mind." (Hamilton, T. & Tucker, N., 2022, 00'20").

Moreover, to underline the high importance of promoting mental health and global well-being, the report 'The Future of Cities' (EC *et al.*, 2019) cites Hayes *et al.* (2015) to assert that severe mental disorders are a primary contributor to global disability, leading to an average lifespan that is 10-20 years shorter than that of the general population. According to the report above, the United Nations has calculated that a significant proportion of individuals with mental illness in low-income countries, up to 75%, do not have

access to proper care. In high-income countries, this percentage still varies between 35% and 50%. The Organisation for Economic Co-operation and Development (OECD/EU) refers that mental health issues affect approximately 84 million individuals throughout the European Union, and the associated costs, both direct and indirect, are considerable (OECD/EU, 2018). In response, many European countries are adopting comprehensive policies that promote mental health and raise awareness.

4. Urban stress cuts across physical and mental health

Stress is a transversal problem that aggregates various organic and psychological disorders caused by diversified stimuli such as physical, emotional, and living conditions, among others. Stress, therefore, affects physical health and mental health. Belonging to the social domain, according to Koene, the study of stress has great scientific relevance to the extent that it is researched from social, psychological, or medical perspectives (Koene, 2018a). According to the same author, "Urban stress is stress in humans, caused by the urban environment" (Koene, 2018b, p. 3).

Although stress and mental disorders occur mainly in urban environments, the physical and spatial causes have not yet been adequately associated (Lederbogen *et al*., 2011; Malta & Marques da Costa, 2021)), at least at the time of reference. However, due to the increasing number of articles that have been published on the topic most recently, there are reasons to believe that will change and soon, more than build evidence on associations between the urbanite and stress and mental disorders, causality is on the way. From this interdisciplinary research endeavour, guidelines to integrate urban planning and public health policies will foster mental health and prevent or reduce mental illness.

Regarding this article's proposal of urban health determinants, it is essential to note that it was considered that these determinants are the ones that, if not considered and taken into account in urban planning, then it may be classified as "urban stressors". On the other hand, if they are part of the urban planning and urban design process, they can be considered beneficial elements that increase well-being, happiness, and quality of life, or as "urban conciliators or restorers" in the positive perspective of these determinants.

IV. IDENTIFYING THE DETERMINANTS OF URBAN HEALTH

1. 'Urban' as a determinant

The knowledge that the built environment impacts health has ancient foundations. Until Hippocrates, health and disease were divine attributions of gift or punishment. In his treatise "Of Airs, Waters and Places", he argued that human nature did not depend on the gods and justified the natural influence of the environment and its geographical factors, as well as the influence of physical characteristics of inhabitants of different regions, on health and disease.

The physical dimension of the places and their inhabitants acquired characteristics that demonstrate differences labelled as urban and rural despite being complementary in their functions in the face of growth and development. However, in a broader view, the 'urban' itself – perceived as a spatial condition and as a way of life – is understood as a determinant of health because it provides unique insights into defining characteristics of cities such as size, density, diversity, and complexity (Vlahov *et al.*, 2007; Marques da Costa *et al.*, 2013, 2020).

The proposed collection of urban health determinants derives from a comprehensive literature review. Here, some initial musings, and key concepts, through the lens of urban planning and urban design, are found, and, as a result, five groups of urban determinants that have a direct or indirect impact on health emerged. Figure 2 illustrates the methodological approach.

Also considering Dahlgren and Whitehead's 'rainbow model of the determinants of health' and the distribution of the levels of the determinants (fig. 3), this article proposes a representation of a 'determinant collection wheel' (fig. 4), which intends to illustrate that any of the determinants can have a negative or positive impact on human health (depending on the conditions in which each one is found). Thus, they can assume the role of 'urban stressors' or 'urban reconcilers or restorers'. Figure 5 shows the seven 'sub-determinants' related to 'urban morphology'.

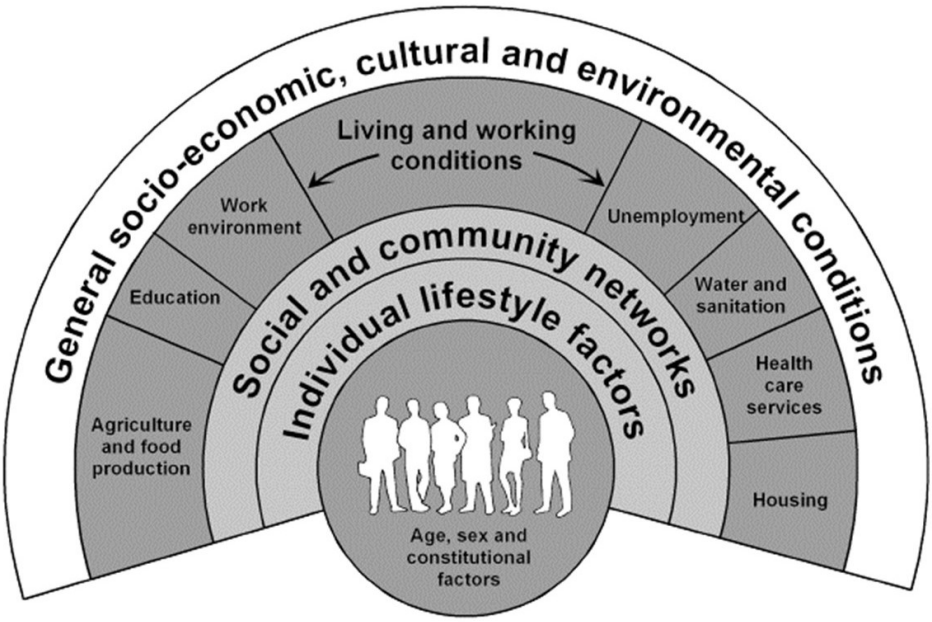

Fig. 3 – Original rainbow model of the determinants of health.

Fig. 3 – 'Modelo arco-íris' original dos determinantes da saúde.

Source: Dahlgren & Whitehead, 1991

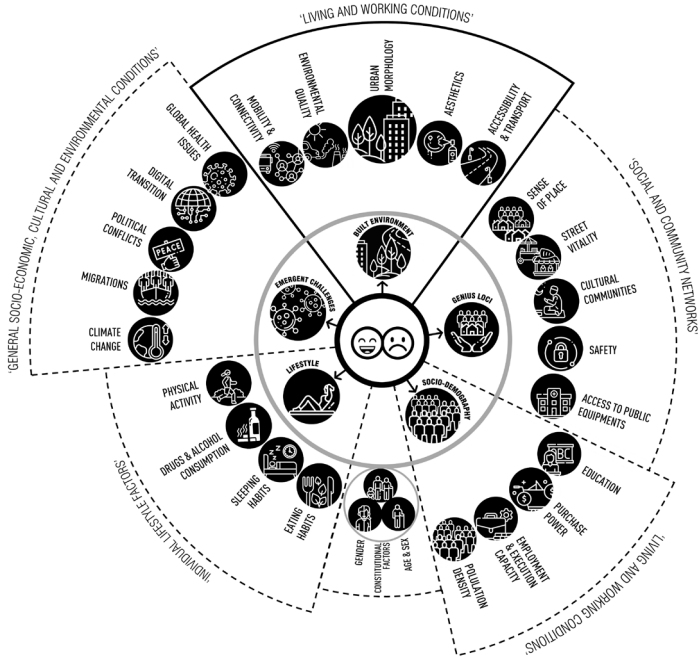

Fig. 4 – Urban health determinants.

Fig. 4 – Determinantes da saúde urbana.

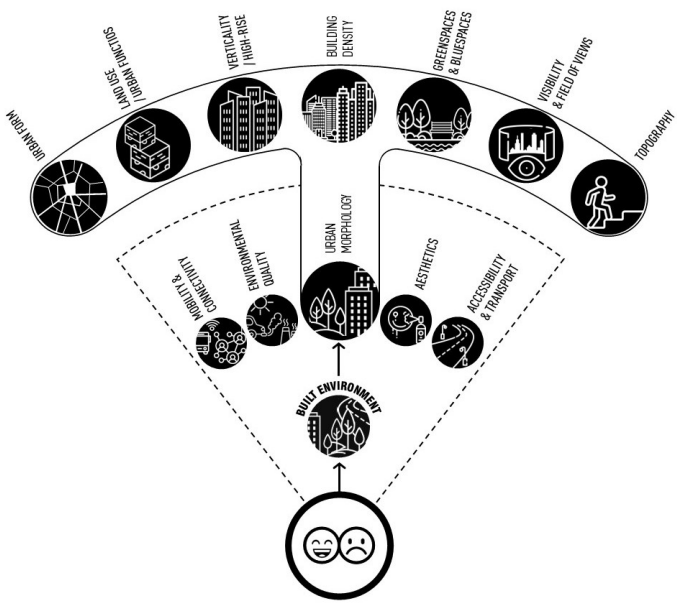

Fig. 5 – Built environment determinants.

Fig. 5 – Determinantes da saúde urbana.

To explain each identified determinant, a table that systematises and summarises the findings across the comprehensive literature review on the relationship between the built environment and physical and mental health was built (table I).

Table 1 – Built environment determinants description and its negative impacts.

Quadro 1 – Descrição dos determinantes do ambiente construído e seus impactos negativos.

DETERMINANTS	NEGATIVE IMPACTS
BUILT ENVIRONMENT – "(…) the built environment have for the inhabitants and the users, or the public or, more correctly, the various publics, since meanings, like the environments that communicate them, are culture specific and hence culturally variable? The point made is that the meaning of many environments is generated through personalization-through taking possession, completing it, changing it. From that point of view the meaning designed into an environment (even if it can be read, which is far from certain) may be inappropriate, particularly if it is a single meaning. What is wrong, I argued, is that we tend to overdesign buildings and oth er environments" (Rapoport, 1982, p. 21). – Built environment "refers to places (be they neighborhoods, towns, or cities) made up of individual buildings, streets and transport infrastructure, public places, and green open spaces. We use the term "planning" as it refers to "town planning" (also commonly known as city, urban, or land-use planning)" (Thomson & Kent, 2017, p. 71). – Buit environment is made up of "buildings, roads, parks, and all other improvements constructed by people that form the physical character of a community" (Kotval *et al.*, 2021, p. 6).	
 **Urban Morphology** – "Urban morphology is the study of human settlements, their structure and the process of their formation and transformation. (…) It is concerned with the form and structure of cities, towns and villages, the way that they grow and change and their characteristics as our habitat. Urban morphology provides a range of concepts and tools that articulate the different aspects and elements of urban form, the relations between them and our role as the agents who create, use and transform them" (Kropf, 2018, p. 9).	
 **Urban Form or Urban Spatial Configuration** – "The term "urban form" is used to describe a city's physical characteristics. It refers to the size, shape, and configuration of an urban area or its parts. How it will be understood, structured, or analyzed depends on scale. Characteristics of the urban form range from, at a very localized scale, features such as building materials, facades, and fenestration to, at a broader scale, housing type, street type, and their spatial arrangement or layout. The concept of urban form encompasses also non-physical aspects such as density" (Živković, 2020, pp. 862-863). – "(…) there is much research revealing that urban areas characterized by a traditional urban fabric are more pedestrian friendly and therefore walkable, so linking these correlations to the effect of neighborhoods versus suburbs on somatic symptoms, anxiety/insomnia, social dysfunction, and severe depression is a natural next step" (Iravani *et al.*, 2021, p. 4).	The less friendly the urban form, the more likely it is to cause: – Alienation – Anxiety – Confusion/ disorientation – Insomnia – Social dysfunction – Depression

DETERMINANTS	NEGATIVE IMPACTS
 **Land Use or Urban Function** – Land-use is "the term used to describe the human use of land. It represents the economic and cultural activities (e.g., agricultural, residential, industrial, mining, and recreational uses) that are practised at a given place. Public and private lands frequently represent very different uses. For example, urban development seldom occurs on publicly owned lands (e.g., parks, wilderness areas), while privately owned lands are infrequently protected for wilderness uses" (Kotval *et al*., 2021, p. 7). – "Urban function can be conceptualized as function of city in relation to the society, hinterland, or other settlements; as activities taking place inside of cities; or as a relation between urban (social) needs and urban (spatial) forms. Urban functions are generator that shape morphological characteristic of urban space. The location, size, and shape of urban space are in direct relation to functional needs of inhabitants or society" (Živković, 2020, p.863).	The lack of functional diversity can cause: – Alienation – Depression – Social isolation
 **Verticality / High-rise** – "Oppressiveness is defined as the negative feeling resulting from being surrounded by high-rise buildings. Building oppressiveness when combined with other urban stresses contributes towards making compact cities unsustainable" (Asgarzadeh *et al*., 2010, p. 555). – "Specific urban designs (*e.g.* tall buildings that may be perceived as oppressive), or more physical threats (e.g., accidents, violence), thereby likely increasing stress levels with negative effects on mental health (…) Moreover, urban street canopy can reduce the "oppressive" effects of tall buildings" (Gruebner, 2017, pp. 124-125).	The taller the building, the more likely it is to cause: – Oppressiveness – Fear – Anxiety – Stress
 **Building density** – "We seek the density of large cities for their variety of leisure activities, rich cultural life, better access to employment and anonymity; but this seems to come at a cost. We may be paying for it with our health" (Adli, 2011, p. 3). – When addressing the issue of density, it encompasses both built and unbuilt spaces. With the current trend of urbanisation, cities are faced with the need to accommodate a growing population, which leads to an increase in population density. The spatial challenge stems from the need for a significant amount of built space, known as building density, to provide housing and support the daily life of the expanding population. Consequently, many cities are forced to build skyscrapers and occupy a substantial portion of available land to meet these demands (Koene, 2018a).	The higher the building density, the more likely it is to cause: – Stress – Anxiety – Mood disorders – Schizophrenia – Depression – Social isolation

DETERMINANTS	NEGATIVE IMPACTS
 **Greenspaces & bluespaces (accessibility and availability)** – "(…) unintentional daily contact to nature through street trees close to the home may reduce the risk of depression, especially for individuals in deprived groups. This has important implications for urban planning and nature-based health interventions in cities" (Marselle, 2020, p. 1). – Greenspaces have been shown to correlate with healthy behaviours and life satisfaction positively. The accessibility and distribution of parks, green spaces and other infrastructure should be considered in urban planning, given their potential to improve physical activity practices (Louro *et al.*, 2021). – "There is an indication that experiencing the natural environment reduces stress levels. The impact of green spaces to mental health also includes improved general mood, reduced depressive symptoms, enhanced cognitive functioning, improved mindfulness, short-term memory performance and enhanced creativity." (Marques da Costa & Kállay, 2020, p. 7). – The emphasis on urban green spaces becomes particularly important due to their scientifically proven contribution to the regeneration of urban areas through ecosystem services. These services can be classified into three categories: provisioning, regulating, and maintaining, as well as cultural benefits (Vidal *et al*., 2021). – "The greenness of European cities has increased by 38% over the last 25 years, with 44% of Europe's urban population currently living within 300 metres of a public park. Well-designed public and green spaces can have a multitude of benefits: improving air quality, providing microclimate regulation, and enhancing safety, social integration and public health" (EC *et al.,* 2019, p. 7). – "Mental health is significantly related to residential distance from parks, with the highest MHI-5 [mental health inventory-5] scores among residents within short walking distance from the park (400m) and decreasing significantly over the next distances. The number of visits and physical activity minutes are significantly and independently related to distance, although controlling for them does not reduce the association between distance and mental health" (Sturm & Cohen, 2014, p. 19). – "Low levels of physical activity have negative implications for the National Health Service [in Portugal] and also for local governments. In fact, the decision-making process at this level should frame the relationships of physical activity practice with the proximity of equipment and the mobility of individuals" (Franco & Marques da Costa, 2021, p. 200). – Bluespaces refer to outdoor environments, natural or built, that prominently incorporate water and are accessible to people either in immediate proximity (being in, on or near the water) or at a distance or virtually, being (in either case) able to observe, hear or perceive the water (Grellier *et al.*, 2017). – Bluespaces encompass various water bodies such as coastlines, lakes, ponds, pond systems, wadis systems, artificial buffer basins, and water courses. When combined with green spaces, they collectively form what is known as the blue-green infrastructure (WHO, 2021).	Inadequate interaction with nature, and the lack of natural spaces, the lack of access to and enjoyment of greenspaces or bluespaces can cause: – Decline in overall health – Nuisances – Stress – Depression – Anxiety – Increased mortality – Increased cardiovascular morbidity – Increased prevalence of diabetes

DETERMINANTS	NEGATIVE IMPACTS
 **Visibility / Field of Views** – Visibility refers to the comparative size of isovist areas, determined by analysing multiple positions and calculating the visibility of regularly distributed positions throughout the environment. Studies have shown a positive correlation between visibility and perceived safety in public buildings, as well as enhanced pedestrian safety (Knöll *et al.*, 2018). – Visibility plays a significant role in human perception of the urban environment. Exercises were carried out to apply research findings on visual perception to architectural and urban design, including Kevin Lynch's contribution, which focused on the city's image. It suggests that mental maps of cities encompass various elements that can effectively represent our experiences and shape our perception of the environment (Leduc & Kontovourkis, 2012).	The lack of visibility and a vast field of view can cause: – Stress – Anxiety – Disorientation – Depression – Nuisances
 **Topography** – "Unless factors like weather conditions or topography are controlled for, our understanding of how built environments influence travel will remain murky. (…) Our research reveals that urban landscapes in the San Francisco Bay Area generally have a modest and sometimes statistically insignificant effect on walking and bicycling. Although well-connected streets, small city blocks, mixed land uses, and close proximity to retail activities were shown to induce nonmotorized transport, various exogenous factors, such as topography, darkness, and rainfall, had far stronger influences" (Cervero, 2003, p. 1482).	A very hilly topography can cause: – Fatigue – Cardiovascular diseases An uneven (flat) topography can cause: – Spatial disorientation
 **Mobility & connectivity** – The adverse effects of commuting by car can manifest in as little as 15 minutes. Numerous factors contribute to stress while driving, including traffic congestion, road construction, long distances, parking difficulties, and more. The unpredictability of the road conditions, the feeling of losing control, and the inability to communicate effectively from within the car are all significant sources of stress in traffic (Koene, 2018a; Louro & Marques da Costa, 2019). – Parking problems make us experience "slavery and alienation" (Levy-Leboyer, 1982). – The scarcity of parking spaces not only leads to stress but also contributes to instances of violence towards others. Various sources suggest that a significant portion, ranging from 20% to 44% of individuals, perceive parking as a stressful experience. This stress is primarily attributed to inadequate parking availability, high parking fees and incorrect parking practices (Koene, 2018a).	Traffic congestion, parking problems, lack of mobility services and lack of connectivity can cause: – Irritability – Anger – Anxiety – Stress

DETERMINANTS	NEGATIVE IMPACTS
 **Accessibility & transports** – Transportation is the "mobility of people, freight, and information and its spatial organization considering attributes and constraints related to the origin, destination, extent, nature, and purpose of movements" (Kotval *et al*., 2021, p. 9). – Transit is "the conveyance of persons or goods from one place to another by means of a local or regional public transportation system. (Kotval *et al*., 2021, p. 9). – Public transport significantly impacts health and health equity, and that influence on health is growing globally, along with increased mobility of people and goods. Road traffic is the most significant cause of community noise in most cities. Community noise exposure has a range of health effects. As well as more general effects such as annoying, noise is linked to stress levels and increased blood pressure. (Transport Policy Advisory Services [GIZ] & WHO, 2011) [See below, "About noise pollution"] – The waiting time during public transport transfers hurts travel satisfaction. Reducing travel time could be a critical factor in reducing stress. The comfort and maintenance of vehicles, as well as the characteristics of road networks, can also affect the well-being of users (Conceição *et al.*, 2022). – Driving in heavy traffic is one of the most anxiety-inducing situations drivers try to avoid. Professional drivers, particularly bus drivers, have extensively studied stress and increased mental workload from congestion (Conceição *et al.*, 2022).	The lack of diversity and frequency of accessibilities and transport can cause: – Unhappy mood – Irritability – Stress – Annoyance – Sleep disturbance
 **Aesthetics** – "The effect of aesthetics on emotions has been documented extensively. We know, for example, that the frequent sight of garbage, graffiti, and disrepair produces alienation and depression, especially among the elderly" (Montgomery, 2013, p. 149). – Signs of social disorder, such as physical decay, vandalism, and litter, significantly generate fear of crime. The deterioration of the physical environment and visible indicators of neglect are interpreted as signs of a breakdown in the social order. Consequently, these signs are associated with the perception of criminal activity, leading to heightened fear among individuals. The connection between the physical environment, social order, and the fear of crime underscores the importance of maintaining and improving the quality of public spaces to enhance feelings of safety and security (Rapoport, 1982). – Sensory cues that suggest positive environmental quality often involve indicators of newness (indicating a perception of low age and absence of obsolescence), an impression of luxury, a well-maintained environment with no signs of degradation or clutter, and a sense of harmony with nature, including elements such as vegetation, open spaces, natural features and privacy (Rapoport, 1982).	The physical deterioration, signs of vandalism and lack of caring can cause: – Alienation – Apathy – Social dysfunctions – Fear – Insecurity – Depression

DETERMINANTS	NEGATIVE IMPACTS
 **Environmental Quality** To determine this indicator, we considered the following factors: 1) **air pollution**; 2) **noise pollution**; 3) **light pollution**; 4) **natural light conditions**; and 5) **urban comfort**. About **air pollution**: – As stated by the European Environment Agency (EEA), air pollution is Europe's most significant environmental health hazard, exerting a substantial impact on the well-being of the European population, particularly in urban regions. Despite notable reductions in emissions of major air pollutants and their concentrations over the past twenty years, air quality remains inadequate in numerous areas (EEA, 2022). – "In the US, the *Air Quality Index is* determined by the maximum concentration of ozone, particulate pollution, carbon monoxide, sulphur dioxide, and nitrogen dioxide, where the concentration of each pollutant is normalized on a unitless 1–500 scale, where a value of 100 corresponds to the relevant national ambient air quality standard" (Gosling *et al*., pp. 279, 280). About **noise pollution**: – Noise is "any undesirable sound because it interferes with speech and hearing, is intense enough to damage hearing, or is otherwise annoying" (Kotval *et al*., 2021, p. 8). – The human ear is the organ responsible for the direct perception of sound and is susceptible to damage when exposed to deafening sounds. Noise, which refers to unwanted, uncontrollable and unpredictable sounds, can be highly uncomfortable and disturbing regardless of their volume. The body can undergo a series of complex physiological reactions, such as stress. These physiological reactions can include increased blood pressure, the excessive release of specific hormones, changes in heart rate or a slowing of the speed of digestion (Bronzaft, 2002). – When individuals residing in high-density residential units experience noise annoyance from their neighbours, the likelihood of having poor mental health increases by 2.3 times. When individuals lack control over the noise, such as in the case of noise annoyance, they may experience learned helplessness and exhibit biological indicators of chronic stress, such as elevated cortisol production (Hoising *et al.*, 2019). About **light pollution**: – "Artificial outdoor lighting extending over its functional role (to enhance visibility or aesthetics in the night-time environment). Light pollution comes in many forms, including sky glow, light trespass, glare, and over illumination" (Kotval *et al*., 2021, p. 8). – Artificial outdoor lighting gradually becomes inefficient, bothersome, and unnecessary. A mounting body of scientific research indicates that light pollution can negatively impact human and wildlife health. One notable effect is the disruption of melatonin, a hormone the pineal gland produces that is typically released during night-time to regulate the body's biological clock. Melatonin plays a role in various biological processes and may reduce the body's production of estrogen during the night (Chepesiuk, 2009).	**Air pollution** can cause: – Anxiety – Autism and child behaviour problems – Cognitive impairment – Dementia – Stress – Mood disorders – Respiratory diseases (asthma, pneumonia, lung cancer, etc.) – Myocardial infarction – Arrhythmia – Heart congestive failure – Cardiovascular diseases – Neonatal disorders – Deep venous thrombosis – Diabetes – Systemic inflammation – Increase in mortality **Noise pollution** can cause: – Annoyance – Sleep disorders or insomnia – Cognitive impairment – Depression – Learning impairment in children – Stress – Tinnitus or deafness – Cardiovascular diseases – Respiratory diseases – Cerebrovascular diseases – Gastrointestinal diseases – Increase in mortality – Reduced cognitive performance in children – Premature deaths – Ischemic heart disease

DETERMINANTS	NEGATIVE IMPACTS
– Modern society has disrupted this essential life cycle by prioritising maximum productivity and neglecting the ecological balance and homeostasis of the human metabolism. The term "light pollution" has now become widely recognised, referring to the presence of artificial light during natural periods of darkness (Harb *et al.*, 2015). About **natural light conditions**: – Light pollution can impact human physiology, and the absence of exposure to natural light has been associated with elevated cortisol levels and reduced melatonin levels at night. These hormonal imbalances have been linked to depressive symptoms and poor sleep quality. Moreover, this disrupted light pattern has been correlated with a higher prevalence of obesity, psychiatric disorders, cardiovascular disease, and breast cancer. It highlights the far-reaching effects of light pollution on various aspects of human health (Harb *et al.*, 2015). About **urban comfort**: – Urban comfort can be considered a set of tangible and intangible factors, from the physical to the social. It cannot be reduced to the thermal comfort already widely studied by science. According to Tavares, urban comfort offers a fresh viewpoint on how local sociocultural values shape responses to climate conditions. It recognises that urban comfort is a cultural construct that places human adaptation at the core of the urban climate experience. The concept suggests that people adapt to the specific microclimate of urban areas when they have motivations, which can differ across cultures. The urban landscape's physical and social aspects are regarded as integral components of the overall climate experience (Tavares, 2017). – In terms of outdoor thermal comfort, Gosling introduces the universal thermal climate index (UTCI) as an internationally recognised standard developed by the European Cooperation in Science and Technology (COST) Action 730. The UTCI is based on current research in thermo-physiological modelling related to human responses. It defines the UTCI as the iso-thermal air temperature of a reference condition that would induce the same dynamic physiological response as the given combination of air temperature, wind, radiation, and humidity (stress). The UTCI measures the strain experienced by individuals in different thermal environments (Gosling *et al.*, p. 301).	**Light pollution** can cause: – Deconcentration / Distraction – Depression – Sleep disorders or insomnia – Obesity – Cardiovascular diseases – Breast cancer The lack of **natural light** can cause: – Sleep disorders – Poor memory – Irritability – Mood disorders – Anxiety – Depression The lack of **urban comfort**, in particular the urban heat, can cause: – Cognitive impairment – Deconcentration – Dementia – Neurodegenerative diseases – Respiratory diseases – Cardiovascular diseases – Cerebrovascular diseases – Hypertension – Breast cancer – Obesity – Diabetes – Metabolic syndrome – Colon cancer – Increase in mortality

Currently, the scientific work that has made it possible to ascertain the factors that condition mental and physical health in an urban context (table I) has mainly come from the fields of environmental psychology in dialogue with architecture and, more recently, with urbanism and urban planning.

The advances made in the technological field allow accessing neural signals in real-time as people interact with the built environment, avoiding the limitations and subjectivity of the studies from environmental psychology. Mobile EEG, health wristbands, wearable eye tracking and other wearable biological devices allow to cross biological data with contextual-geographical data and explore associations (Neale *et al.,* 2019; Pykett *et al.*, 2020).

V. FINAL REMARKS

Although urbanisation and city living offer many socioeconomic advantages, they can also be stressful. Today, there is a growing recognition that health, specifically mental health, must be addressed considering the social and environmental context. Therefore, health inputs are critical to urban planning, as mental health/illness is highly correlated with the urban environment and lifestyle. However, we argue that insufficient work has been done to integrate neuroscience content into urban planning and design.

To create healthier and sustainable cities and promote general well-being, urban planning must adopt neurourbanism principles. This means capturing brain signals triggered by the built environment stimulus and objectively uncovering how these impact people's perception, cognition/emotions, and behaviour.

A healthy city and community contribute to citizens' empowerment which in turn raise awareness on politicians and professionals to take action and address risk factors, *e.g.* noise, pollution, traffic jam, high density, accessibility, lack of green spaces and shadows, etc., that impact negatively on peoples mental health and well-being.

Similarly, urban planning and design can positively contribute to mental health. Having scientific evidence on what type of built and natural environment triggers positive emotions, promotes physical activity, and reduces stress and anxiety levels will inform urban planners and designers and empower them to (re)design healthier and more people-friendly cities.

The consolidation process of this new discipline, whose empirical evidence has claims to be fundamental for the future of cities and citizens, involves finding scientifically sound answers to a set of still open questions, such as:

- When and where will neuroubanism be practised?
- Who will be the agents disseminating and practising the discipline?
- Will the Academy only educate this new discipline, bringing together neuroscience and urbanism?
- Hou urban design of public spaces can be re-designed?
- How to integrate co-creation and place-making within neurourbanism?
- How to involve local communities and stakeholders in the process?
- Will health centres be the first vehicle for the practice of neurourbanism, where, for example, family doctors (with complementary training in the new discipline) may prescribe the directed fruition of urban spaces, greenspaces or waterfronts instead of anxiolytics and antidepressants?

- Which spatial planning toolkit integrates guiding measures coming from neurourbanism?
- How to have citizens as reliable sources of information?
- What methods and techniques should be adopted to produce, capture and analyse data?
- Who is responsible for producing and disseminating such data at the neighbourhood/street scale level?

The relevance of this issue was pre-pandemic; however, it was covid-19 pandemic that brought people's attention to the importance of mental health and its relationship with the built environment. The European Union created a 'European Urban Health Cluster' before the pandemic under the theme 'Innovative actions to improve urban health and well-being', addressing environmental, climatic, and socio-economic factors to optimise synergies and promote urban health in the European Urban Agenda.

There is a long-term search to identify urban variables and indicators related (directly or indirectly) to mental health, at different scales, with different natures and typologies; being very difficult to set universal parameters given the territorial and cultural differences of the multiple territorial settings analysed. For this reason, the diversity of social contexts, case studies and scales of analysis and the non-inclusion of factors of cultural contexts are pointed out as limitations in most articles. The lack of use of technology to obtain quantifiable biosensory data are also some of the limitations detected. Therefore, scientific papers often restrict their analysis to "empirical evidence" surveys and policy documents. The evidence results mainly from experiences in urban spaces, by structural or ephemeral interventions or by the absence of either, whose conclusions result from continuous observation, are not always standardised and constitute empirical knowledge in continuous development.

In the relationship between what is scientific and what is empirical, science must continuously add new knowledge to what has already been acquired, respond to new challenges, and draw inspiration from reality. Public policies should seek robustness in this new scientific knowledge. Based on evidence from current projects (such as the ones forming the Urban Health Cluster) and future ones, by 2050 (when an estimated two-thirds of the world's population live in cities), neurourbanism must be a full-fledged discipline.

This article stands as a contribution towards that end. However, future research is currently under development to dive more in-depth into the topic, namely to 1) find indicators that can make the determinants measurable; and, consequently, 2) to define actions that can be translated into public policies on urban planning and health. Moreover, with the general recognition that science supports the better decision and help policymakers to meet people's needs, it is anticipated that will be opportunities for more pilot studies on human-scale, which in turn will push authorities to provide more meaningful and trustworthy data with suitable scale granularity and that can be systematically produced and collected, and integrated into urban planning, and from there to the street's realm.

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