MENTAL HEALTH AND THE URBAN ENVIRONMENT: A BIBLIOMETRIC MAPPING OF KNOWLEDGE STRUCTURE AND TRENDS

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ABSTRACT

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The literature on the urban environment, health, and well-being has steadily increased over the last decade. This paper aims to offer a better understanding of the state of the literature on assessing the urban environment and health through mapping the field of research through a scoping review and illuminating emerging trends and future research using keyword frequency and bibliometric analysis. Uniquely, this study drew 495 articles from four distinct journal databases (PubMed, Scopus, Web of Science, and ProQuest), whereas traditional bibliometric analyses draw from a single source. By drawing from a broader base of knowledge, this study offers a more holistic view of the trends in the field of research on the connection between urban environments and well-being to better identify future research pathways. The results show trends of a consistent increase in research on the topic over the last decade. Research published on this topic is fragmented, with consistent but isolated focus on physical health, mental health, and environmental characteristics. Overall, in this field, physical health is most often assessed in relationship to the urban built environment, while mental health is most often assessed in connection to the urban natural environment. This paper also provides information on influential authors in this field of research. This study concludes by highlighting gaps and making recommendations for future research in the field. Prominent gaps are related to using interdisciplinary and scalable approaches to understanding the relationship between urban environments and overall well-being.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1. INTRODUCTION

By mid-century, 68% of the projected global population is expected to live in urban areas (United Nations, 2017). Urbanization will need to expand and adapt to safely accommodate the estimated 6.7 billion global residents (United Nations, 2018). As has been seen over the last few decades in developing countries quickly increasing urbanization to account for increasing urban populations safely, urbanization can have deleterious impacts on the health of residents and the environment in the form of pollution, traffic accidents, climate change, and social unrest (Kjellstrom & McMichael, 2013; Custot et al., 2012). Faced with the challenge of increasing urban populations, municipalities' charge of promoting public health will continue to grow in urgency, as even today just under 1 in 4 deaths are caused by unhealthy environments (Pruss-Ustun et al., 2016). The built and natural environments of urban areas fall within the purview of municipalities, and the connections between the built and natural environments and health and wellbeing are extensive and complex (Renalds et al., 2010).

The preponderance of global health initiatives promoting 'healthy cities,' indicates an international political recognition of the importance of urban environments' influence on public health, such as the World Health Organization's "Healthy Cities Initiative," Bloomberg Philanthropies' "Partnership for Healthy Cities," and the USAID's "Build Healthy Cities" program (WHO, 2020; Bloomberg Philanthropies, 2021; USAID, 2020). The Healthy Cities Movement rose to prominence in the 1980s in Europe, and quickly became a popular global issue (Tsouros, 2019). The foundational values of the movement are to create "supportive environments for health," make "healthy choices the easy choices," create "healthy settings, schools, workplaces, universities, health centres, and neighbourhoods," and empower "individuals and communities" (Tsouros, 2019). The Healthy Cities Movement promotes

institutional and political support of taking intersectoral action to achieve their Health in All Policies approach, which engages a holistic approach to health in society (Tsouros, 2019). The Healthy Cities Movement has been found to be critically important in connecting health and planning efforts through disseminating and creating good practice, and thereby transforming the political and professional agenda and integrating health and sustainable development (Barton, 2012). However, the movement still faces institutional and market barriers to influencing spatial form (Barton, 2012).

The connections between physical health and the urban environment have been well-studied. The morphology of the built environment has been shown to directly impact physical health, with increased physical activity, increased social capital, lower body weight, lower depression reports, and reduced alcohol abuse (Renalds et al., 2010). Most studies of the relationship between physical health and the built environment focus on measuring objective indicators such as income values, crime rates, and environmental conditions like noise, air, and light pollution (Krefis et al., 2018). The positive impacts of physical health extend to mental health as well, with studies showing strong cross-effects between physical and mental health, and physical activity even being used as a preventative and retroactive treatment for depression (Ohrnberger et al., 2017, Kok and Law, 2019). The built environment has the potential to impact physical health both positively and negatively, underscoring the importance of intentioned planning and policy efforts that integrate a health perspective.

Mental health is a multi-faceted issue, with no one driving force, but instead with many contributing factors influencing the mental health of an individual. Studies have shown that risk factors like stress, relationship conflict, socio-economic and social changes, and even cultural components can negatively influence the mental health of youth; while connectedness, social

supports, and cultural richness have been shown to be protective factors against the development of mental health issues (Kok and Low, 2019). Similar to its relationship with physical health, the built environment can also impact mental health to an individual's benefit or detriment. For instance, place attachment, which can be understood to mean the psychological and social connections people feel with specific places such as their home or neighborhood, can function as a protective factor against developing mental illness (Sullivan and Chang; Kok and Low, 2019). On the other hand, certain aspects of urban areas can negatively impact mental health and psychological states, for example, crowds, noise pollution, and dangerous settings can promote stress, anxiety, depression, and even violent behavior (Kok and Low, 2019). Additionally, mental health and well-being have been correlated with perceptions of higher degrees of social capital amongst neighbors, indicating that perceptions of a greater community investment, feelings of safety, and connections can promote and preserve mental health (Renalds et al., 2010). The spatial arena of a community is not a neutral place without influence on the mental health of individuals or a community, instead it contains the potential to facilitate or hinder well-being.

The relationship between the built environment and human well-being has been studied in a wide variety of fields, including but not limited to urban planning, the natural sciences, public health, and epidemiology. In general, "well-being" is understood to be a state of being comfortable, health, or happy and it is often interchanged with other terms like "happiness," "life satisfaction," and "quality of life" (Krefis et al. 2018). While the term "well-being" is multiplicitous and nuanced in a broad sense, with a collection of competing definitions (Dodge et al., 2012; Krefis et al., 2018), it is commonly accepted to be composed of both physical and psychological health components (VanderWeele et al., 2020, Szombathely et al., 2017). Szombathely's UrbWellth Model is an interrelated model defining "well-being" as having

connected domains of physical health, mental health, emotional health, environmental health, political systems, social function, and social context (e.g. socio-economic status) which all operate within the urban areas in which people live (2017). Unsurprisingly, the intricates of the interconnected domains of the UrbWellth model mirror the myriad of contributing factors in public health in general. However, most studies of well-being focus on the built environment and general health (Rydin et al., 2012), urban factors and specific health characteristics, such as air pollution or stress (Faustini et al., 2011; Moskowitz et al., 2013), or focus on associations such as access to urban parks (Nutsford et al., 2013) as those factors are more readily assessed.

Overall, the built environment actively shapes well-being and health, both physically and psychologically, and exploring the state of the knowledge regarding those complex and interconnected relationships is required to better understand how to design and implement planning, policy, and direct future research. Extensive research has been performed examining the relationship between physical activity, health, and urban space such that it has influenced public polices since the late 1990s in the United States (National Research Council, 2005). However, the second component in the relationship between urban space and health, mental health, has been understudied. In light of the mental health crisis caused by the recent global pandemic, which called for the public to participate in mass quarantine in their homes with limited use of urban areas excepting urban green spaces, the relationship between mental health and the built environment is extremely relevant to general public and academic study (Houssain et al., 2020). Therefore, the aim of this paper is to examine the nature of the relationship between urban spaces and mental health through examining of the state of the literature on the topic. The research area is multidisciplinary with research ranging from urban planning to sociology to environmental studies to healthcare sciences. This research aims to clearly assess the state of the

current research, analyze the direction of the field and the factors and components of popular study in this field, identify research gaps, and make predictions regarding potential directions of study for researchers in the field of urban planning.

CHAPTER 2. LITERATURE REVIEW

2.1 Connection between the Built Environment and Physical Health

The relationship between the built environment and physical health has been long studied from a variety of perspectives ranging from physiology to public health to sociology. Primarily, the measurable intersection between the built environment and physical health has been the use of urban spaces, such as physical activity in parks or the walkability of a neighborhood. Extensive research has shown a positive relationship between physical activity in urban spaces like parks and increasing beneficial physical health attributes like cardiovascular health (Lovasi et al., 2011). Additionally, numerous studies have studies have shown that walkable neighborhoods, which are characterized by dense land use and well-connected public transportation, have been connected to a reduction in coronary heart disease, obesity risks, and other detrimental health conditions (Lovasi et al., 2011; Bird et al., 2018; den Braver et al., 2018; Malambo et al., 2016). The built environment has a well-established impactful connection to public health, especially physical health.

While the direct health impacts of using the built environment are often related to activity and movement, indirect negative impacts of the built environment on health have also been explored. Environmental conditions created through the materials in the built environment can inadvertently impact health, such as lead paint or asbestos (O'Conner et al., 2018; Zha et al., 2019). Additionally, the pollution present in the built environment can have detrimental health impacts. For instance, air, noise, water, and light pollution created by the built environment have all been shown to have negative effects on the health of urban residents (Landrigan, 2017; Schewla, 2000; Pandey, 2006; Chepesiuk, 2009). As the built environment can have both long-lasting damaging and beneficial impacts on physical health, planning and policies can influence the intricate relationships within public health well-beyond original intentions.

The complex connections, both direct and indirect, between physical health and the built environment have been well-examined. Less focus has been placed on the intricate relationship between the built environment and mental health. The effects of the built environment and mental health is a newer topic of study with increasing interest across diverse fields; however, there remains a need for more robust studies and interdisciplinary research involving public health, planning, and urban design (Moore et al., 2018).

2.2 Urban Green Space and Mental Health

Current research into the connection between the built environment and mental health has been primarily concerned with urban green spaces. Urban green spaces can provide a variety of ecosystem services, many of which have impacts on public health, mental and physical. The term "urban green spaces" refers to a broad variety of natural areas in a city such as parks, reserves, sporting fields, riparian areas, trails, gardens, and nature conservation areas (Roy, Bryne, Pickering, 2012). Urban green spaces vary in size, vegetation cover, biodiversity, environmental quality, proximity to public transport, and other facilities and services (Dahmann, et al., 2010; Fuller & Gaston, 2009; Sister et al., 2010). Urban green spaces, like all ecosystems, provide not just economic value, but measurable services such as air filtration, storm water runoff reduction, water filtration, and energy cooling effects (McPherson, 1992). While many ecosystem services are quantifiable, many are not measurable in such a manner, for instance, the cultural value created by a neighborhood park that facilitates community activities lends itself to qualitative study (Lee et al., 2020). Due to the provision of these ecosystem services, park access has been linked with increased physical activity, reduced risk of mortality, reduction in obesity, and decreased psychological stress (Coutts et al., 2010; Evenson et al., 2013, Diez Rouxet al., 2007; Mennis et al., 2018).

Over the last few decades, there has been extensive research delving into the complex relationship between urban green space and health benefits. In the research, in addition to physical health benefits, the psychological or mental health impacts of green space exposure have been of particular interest to researchers. Research has shown that urban green spaces can supplement treatment for mental illnesses, depression, and fatigue (Nichani et al., 2017; Beyer et al., 2014). Additionally, studies have linked reductions in physiochemical stress and neurological fatigue responses (salivary cortisol amounts and brain waves, respectively) to urban green space exposure (Roe et al., 2013; Aspinall et al., 2015). Illuminating the theoretical underpinnings behind the connections between urban space and health is key in creating a better understanding of the state of current knowledge in the field.

2.3 Theories Behind Urban Green Space and Mental Health

Researchers have long sought to explain the connection between urban green space and mental health through psycho-evolutionary theories. Psycho-evolutionary theories seek to explain brain structure, cognition, emotions and psychological responses through the lens of evolution, meaning that these biological and psychological responses can be attributed to adaptations to a physical or social environment. In 1981, Ulrich proposed Stress Reduction Theory which states that natural settings facilitate recovery from stress in humans, while conversely urban environments increase physiological and emotional stress responses and reduce stress recovery times. Nearly a decade later, Ulrich et al. (1991) developed Stress Recovery Theory which postulates that exposure to nature, combined with an initial positive affective (emotional) response, results in restorative physiological and psychological responses such as a broad shift towards positive emotions, positive changes in activity levels in physiological systems (cardiovascular and endocrine), and high levels of sustained attention (Ulrich et al.

1991). In 1989, Kaplan and Kaplan proposed an alternative hypothesis, Attention Restoration Theory (ART), which states that time spent in restorative environments can help increase and restore concentration and attention in individuals (Kaplan, 1995). Stress Recovery Theory and Attention Restoration Theory are often mentioned in tandem, as they tackle similar concepts but from fundamentally different perspectives.

The connection between general and mental health and green spaces is intricate and influenced by many confounding factors, such as socioeconomic and cultural backgrounds (Lee et al. 2019; Lee et al., 2020). Research into these confounding factors have underscored that exposure to green spaces has a stronger impact on the health of those in lower-status socioeconomic groups (Lee et al. 2019; Engemann et al. 2019; Engemann et al., 2020; Boers et al., 2018; Thompson et al., 2012). Individuals in these groups, such as the elderly, are often more home bound and dependent on their local built environment, such as their neighborhood park, for healthy activities (Gong et al., 2014; Gong et al.; 2016). From a social justice perspective, urban green spaces can offer a cost-effective opportunity to shrink systematic health disparities through infrastructure improvements (Hartig, 2008). Acknowledging the myriad of influencing factors beyond the realms of physiology and psychology, theorists began moving away from being grounded in psycho-evolutionary theory to embrace more complex social factors in the relationship between green space and health. The Socio-ecological Theory was popularized in the 1990s, and posits that humans are at the center of a complex system wherein their behaviors are influenced by wider socio-economic, cultural, and environmental systems in which they live; and individuals' decisions are not solely dependent on individual characteristics but rather influenced by a composite of environmental and community factors (Dalhgren and Whitehead, 1991). Additionally, Socio-ecological Theory also differentiates between adults and children,

recognizing that children develop in the context of multiple environments, inside the home, as well as outside the home in the surrounding neighborhoods, schools, and society as a whole (Alderton et al, 2019).

In the field of the built environment and emotional and mental health, there have been few studies assessing the entire state of the field. One method to broadly assess the current state of the literature and existing gaps on a given topic is to perform a bibliometric analysis to identify future research to expand the field. Bibliometric analysis is a statistical method used to visualize the temporal changes and trends through systematic analysis. Several tangential bibliometric studies have been performed in recent years. In 2019, Wang and Yang, examined the state of the research on walkability, concluding that walkability is often discussed in the literature in terms of physical health and the environment. In 2020, Meng et al. published a bibliometric analysis examining the relationship between urban street space and public health. In 2021, Liu et al published a bibliometric analysis of green environments and public health; however, the study primarily identified key connections between public health and a variety of environmental topics (wetlands, marine systems, environmental science, biotechnology and microbiology). Currently, there is no bibliometric analysis that specifically addresses mental health, well-being, and the built environment.

As there is a lack of studies examining the intricacies of the relationships between well-being, mental and emotional health, and the built environment, the objective of this study is to first do a scoping review of the literature on built and natural environments and mental health and wellbeing, and then to comprehensively analyze the selected contemporary journal articles on the interrelated pathways through bibliometric mapping and publication trend analysis. A bibliometric approach to systematic reviews of the current knowledge base allows researchers

new to the field to understand the historical intellectual shifts in the field over time, and more easily identify areas for future research. Furthermore, such an approach can give researchers a more rapid and in-depth comprehension of the topic by understanding influential focus areas and authors highlighted by the bibliometric analysis. In fast-growing fields, bibliometric mapping can facilitate the identification of emerging and understudied areas of a topic.

CHAPTER 3. METHODS

3.1 Data Collection

In order to answer the research question on the nature of the relationship between urban spaces and mental health, a scoping review was initially performed to collect relevant articles. This study conducted a scoping review of articles scanned from PubMed, Scopus, Web of Science, and ProQuest on Urban Environments and Health for journal articles published in English and from the year 2010 to 2021. With an initial number of 57 keywords in each of the two topics listed above, the search returned over 7 million articles. Following multiple brainstorming sessions and search iterations where keywords were refined and narrowed down, the final scan resulted in 10 search terms in Urban Environments (Built or physical or urban and environment; urban design; urban form or urban morphology; garden or park; green space; walkab*; thermal comfort and acoustic comfort; urban planning; public space; urban mobility) and 4 in Health (cognit*; mental health; emotion; psychological) returned 6,902 articles. After removing irrelevant articles and duplicates, we were left with 495 articles to include in the review.

3.2 Measurements

3.2.1 Scoping review and Topic analysis

To answer the research question, this study first performed a scoping review which provided results broadly describing the nature of the relationship between urban space and mental health and well-being. The review results were tabulated in an excel table where the following information was extracted from each article: Theory, Data Source, Variables, Analyses conducted, Results, and Limitations. This information was then categorized into similar topics and themes. We then applied basic inferential statistics to the review results to extract information such as the most common topics, themes, and theories used in the literature. This

information was used to generate rates, percentages, frequencies, and graphs in the scoping review.

3.2.2 Journal and Author Trends

The journals (n =195) and the author affiliations (n =500) of all the articles in the dataset were extracted and processed into research fields. If the title of the journal did not reveal the research field alone, then the journal's online description was used to identify the field. In a similar fashion, the author affiliations were made based on their author information in the articles themselves. If the department information of the author was not sufficient to identify the author's affiliation with a research institute, or field of study, their online biographies were used. If no biographies were found, they were excluded from this analysis.

3.2.3 Keyword extraction

In order to better understand the numerous factors and components in the studied relationship between urban spaces and mental health, a keyword extraction was performed. Keyword extraction can be performed on any collection of texts, such as scientific articles, news, or even social media posts. This study utilized articles that were used in the review/meta-analysis. In this study, an independent document-based approach is applied to keyword extraction. In this approach, the keywords are extracted from each document without considering keywords from other document collections. The process of keyword extraction applied the keyword processing software Cortical.io to each abstract. The keywords extracted from Cortical.io were compared to the original keywords listed in the articles (often chosen by the article authors themselves) and were found to be similar yet contained nuances (particularly in regards to analytical method types, but this can be attributed to the use of only the abstracts and not the entire article). The keywords were then added to the article database manager, from

which an RIS file was extracted to then be used for further analysis. Subsequently, plural duplicates (i.e. parks and park) were removed, alternative English spellings (i.e. neighbourhood for neighborhood) were accounted for, and variants of the same root word (i.e. pollutant and pollution when both occurred in the same extraction) were removed from the keywords extracted.

3.2.4 Keyword Cloud

In order to identify leading topics in the field, a keyword cloud was created to visualize the extracted keywords. Using the Tagcrowd software, the researcher was able to create word clouds based on the frequencies of keywords found in the literature form the keyword extraction. The keywords used in the keyword cloud were the same keywords utilized in the bibliometric analysis. The frequency threshold was set at 20 to maintain continuity with the bibliometric analysis. Words that pertained to process or methods were excluded from the keyword cloud generation (i.e. analysis, approaches, assessment, associations, context, data, effects, evidence, findings, levels, measures, model, outcomes, questionnaire, questionnaires, regression, studies, understanding, variables). The top 25 keywords were selected and visualized in a graphic, wherein the frequency of the keyword is correlated with the size and vividness of the keyword itself.

3.2.5 Bibliometric analysis

After extracting the keywords from the reviewed articles and identifying leading topics in the research area, the relationships between those topics was examined using bibliometric analysis. As a statistical method, bibliometric analysis is used to better understand the temporal changes and trends in given literature bases through systematic analysis. Bibliometric analysis uses software to create network diagrams based on a given dataset. Typically, the analysis is

performed on a co-citation nexus, keyword linkages, and/or co-author associations. Diagrams display the strength of connections amongst articles based on the chosen dataset, allowing researchers to visualize and measure the impact of various trends in the literature. Bibliometric analysis assists researchers in identifying the current state of the literature and existing gaps in the knowledge base to pursue for future research to expand the field.

The keywords extracted from the previous step were then fed into VosViewer for bibliometric analysis. VOSviewer is a Java application that analyzes and visualizes bibliometric networks. Bibliometric visualization software applications can provide information on major thematic focus areas. Additionally, these applications can be used to better grasp the intricate interrelationships between various underlying components of a given research field through tables and network maps. The applications can analyze a dataset of articles for several factors, including term co-occurrence, citation, co-citation, and bibliographic coupling relations. The application is freely available to download (VOSviewer at: https://www.vosviewer.com/). The application website also offers free access to user manuals that provide detailed information on various bibliometrics analysis techniques and various steps that should be taken for data pruning and analysis (Sharifi, 2020).

By sourcing articles from several journal databases, each of which has a different composition of data found in their available citation information, there were limitations to the extent of the bibliometric analysis that could be performed. However, using data from various journal articles offers a more holistic examination of the state of the literature on a given topic. VOSViewer was used primarily to conduct only two types of analysis: term co-occurrence and citation analysis. Term co-occurrence analysis identifies frequently co-occurred terms and thematic groupings that create an intellectual basis in the given field (Sharifi, 2020). Citation

analyses were conducted to identify and categorize the most influential authors in the field (Van Eck, 2009). Citation analysis identifies influential authors in a dataset based only on the citation data of the documents retrieved from literature search. Analyses not performed are bibliographic coupling, and co-citation analysis due to the variable nature of the dataset compositions. Co-citation analysis is similar to citation analysis, but it examines the frequency at which authors co-cite other articles, this analysis can then be used to examine influential publications, authors, and journals between articles in the research field (Sharifi, 2020). Bibliometric coupling measures the similarity between documents, which is then used to identify the countries and institutions that play significant roles in the field (Sharifi, 2020).

CHAPTER 4. RESULTS

4.1 Scoping Review

The following information was extracted from each article: Theory, Data Source, Variables, Analyses conducted, Results, and Limitations. All information was then categorized into similar topics and themes. The following sections summarize the main results of this review.

4.1.1 Theories Utilized

In total, approximately 105 theories were mentioned by 180 different articles (Fig.4.1). The most mentioned theory in the literature was Kaplan and Kaplan's Attention Restoration Theory, which was mentioned 27% of the time. Ulrich's Stress Reduction Theory was the next most mentioned theory in the papers reviewed, at 13% of the time. Psycho-evolutionary Theory was broadly mentioned approximately 2.5% of the time. Other common theories mentioned were Appleton's Prospect -Refuge Theory, Socio-Ecological Theory, and the Theory of Planned Behavior which were each mentioned approximately 2% of the time.

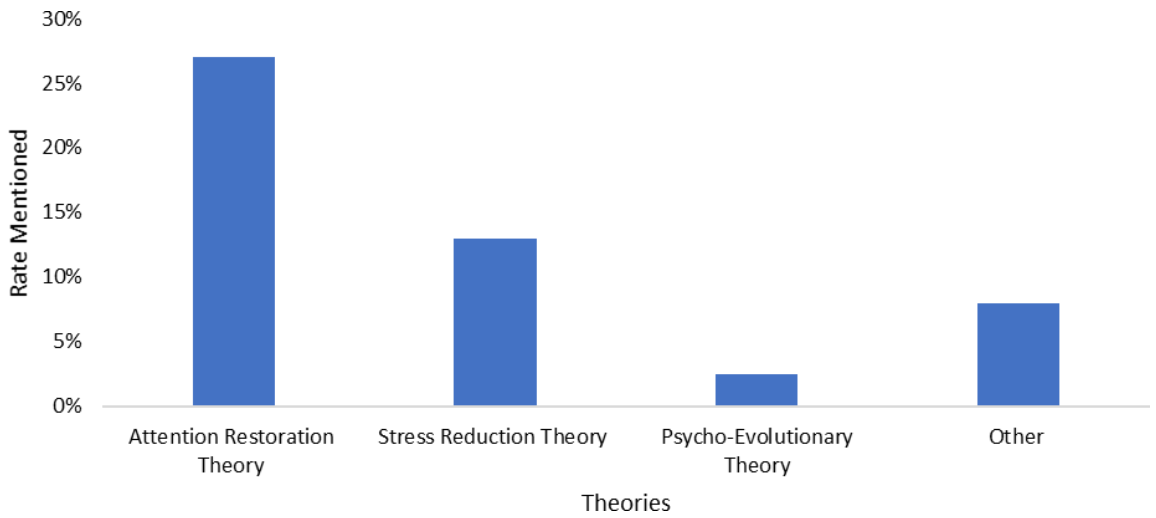


Figure 4.1 The mentioning rate of the theories found in the literature examined (n = 105).

Overall, the theories extracted in this review are seminal works in the field of psycho-evolutionary theory and the environment, each providing the foundations for subsequent theories. The first of which was proposed in 1975 by Appleton, a geographer, the **Prospect - Refuge Theory (PRT)** *states that human preference for landscapes derives from feelings of safety and pleasure in environments that offer both expansive views as well as a sense of enclosure*. Fundamentally grounded in evolutionary theory, PRT explains human environmental preferences as a desire for survival. Environmental landscapes that provide clear opportunities (prospect) for visual and/or audial control while offering safe places to hide and shelter (refuge) are the most preferred natural settings to humans (Appleton, 1975). A more modern application of this theory shows that study participants describe similar features of refuge and prospect as important for emotional expression and self-regulation- "in sheltered and safe supportive locations with a clear view of the surroundings" (Palsdottir et al., 2018). In general, this theory connects aesthetic preferences with real or symbolic elements that are beneficial for survival.

In 1981, Ulrich proposed the second most common theory found in the literature review, **Stress Reduction Theory (SRT)** which is a psycho-evolutionary theory that states that natural settings facilitate recovery from stress in humans, while conversely urban environments increase physiological and emotional stress responses and reduce stress recovery. According to the theory, having evolved in natural landscapes, humans have adapted to positively engage with natural environments over urban settings. Theoretically, humans have adapted to respond to unthreatening natural settings with reductions in human physiological responses in the cardiovascular and endocrine systems. To view the issue from the opposite perspective, chronic high levels of stress in response to a natural setting would be maladaptive due to the resulting

elevated levels of fatigue, stress, and secondary negative health effects (Ulrich, 1981). Additionally, genetic inclinations for sustained fear and avoidance responses would inhibit the exploitation of the natural refuge's advantages and resources (Ulrich, 1993).

One year later, following the development of the Stress Reduction Theory, Ulrich developed the Theory of Affect Responses to Natural Environment (TARNE). This psycho-evolutionary theory contends that humans' evolutionary heritage in natural landscapes underpins human preference for exposure to stimuli from natural settings. The TARNE postulates that in visual encounters with natural settings, aesthetic responses (feelings of like-dislike, personal preference) occur before and shape subsequent cognitive appraisals of the environment, which can then in turn, shape the individual's initial affective response (emotions) (Ulrich, 1983). Ultimately, this theory brought a new concept to the forefront of this topic, that affect (emotional responses) and aesthetic responses (personal preferences) precede cognitive reactions to environmental stimuli. Ulrich (1983) proposed that views will have high aesthetic responses if the unspectacular environment has several properties:

1. Complexity is moderate to high.
2. The complexity has structural properties that establish a focal point, and another order or patterning is also present.
3. There is a moderate to high level of depth that can be perceived unambiguously
4. The ground surface texture tends to be homogenous and even and is appraised as conducive to movement.
5. A deflected vista is present.
6. The appraised threat is negligible or absent.

On the other hand, natural settings with low preference will contain:

1. Either low complexity or unstructured high complexity with no focal area.
2. Restricted depth.
3. Rough, uneven ground surface textures that are obstacles to movement.
4. Absence of both a deflected vista and water feature.
5. High appraised threat.

While TARNE was not directly mentioned in the literature review, it is an key theory in the development of the field overall, and subsequent theories which were found in the literature.

Two years later, the Biophilia Hypothesis was proposed by E.O. Wilson in 1984, and states that humans innately respond positively to natural environments, and this disposition is genetic in part. In 1970, Seligman proposed the biologically prepared learning theory which states that humans and animals are predisposed to easily and quickly learn, and retain, associations and responses that foster survival (Seligman, 1970). Biologically prepared learning plays a role in positive (biophilic) responses to unthreatening natural settings including liking/ approach responses; stress recovery responses; and higher-order cognitive functioning (Ulrich, 1993). Focused primarily on the restorative effects of nature from an evolutionary perspective, according to Ulrich, the speed of recovery, reduction in negative emotional responses such as fear and aggression, decrease in taxing and deleterious sympathetic nervous system mobilization (such as blood pressure), and pronounced parasympathetic nervous system involvement that would be associated with the recovery or maintenance are all characteristics that support the biophilia hypothesis and prepared learning theory (1993). More recently, it has been proposed that technological advances, primarily the internet of things, are increasingly driven by the biophilia hypothesis as vehicles of natural connection instead of disconnection (Sanzaro, 2018).

The most mentioned theory in the papers reviewed, Attention Restoration Theory (ART), was proposed by Kaplan and Kaplan in 1989, and states that time spent in restorative environments can help increase and restore concentration and attention in individuals. The theory is based in the neurological concept of directed (or voluntary) attention, which requires willful effort, functions under voluntary control, is central to achieving focus, is susceptible to fatigue, and through the use of inhibition controls distraction (Kaplan, 1995). As directed attention is a finite and depletable resource in humans, prolonged efforts to exert attention and concentration result in directed attention fatigue. A key component to ART is the role of restorative environments to reduce this fatigue. Restorative environments are natural landscapes with an abundance of soft fascinations which are stimuli that do not require directed attention but effortless (involuntary) attention. Fascinations are innately interesting stimuli and range from hard fascinations like watching a sporting event to soft fascinations like listening to a gentle waterfall. To qualify as a restorative environment, Kaplan (1995) proposed several criteria:

1. Being away from one's regular routine and mental demands. One need not leave their space, simply changing the direction of one's gaze or viewing the same space in a new way can be a sufficient conceptual shift to "get away."
2. The environment must have extent, or rather, the space must be rich in both stimuli and coherence so as to constitute an environment. Rapid and disconnected but fascinating stimuli does not qualify as an environment but as a sequence of impressions. The environment must be sufficient in scope so as to provide enough to see, experience, and think about to occupy enough of the mind to reduce the use of directed attention.

3. Compatibility between the individual's purposes and inclinations and the environment itself is essential. The activities inherently appropriate to an environment must align with the comforts and purposes of the individual (Kaplan, 1983).

Stress Reduction Theory lends itself readily to explaining the psychological impacts of exposure to fascinating but restorative spaces, which are not limited to green space or even non-urban spaces. An important component of Stress Reduction Theory posits that the environment must be suited to the individual's inclinations, for instance, someone who dislikes the natural areas may find a pleasant plaza or square to reduce stress. It is only in combination with the Biophilia Hypothesis is the preponderance of preferences for natural areas and urban green spaces explained.

Nearly a decade after proposing Stress Reduction Theory, Ulrich et al. (1991) developed a new psycho-evolutionary theory combining key features from the TARNE and SRT theories: Stress Recovery Theory. Stress Recovery Theory postulates exposure to nature, combined with an initial positive affective response, results in restorative physiological and psychological responses such as a broad shift towards positive emotions, positive changes in activity levels in physiological systems (cardiovascular and endocrine), and high levels of sustained attention (Ulrich et al. 1991). While the theories are similar, they differ primarily in that Ulrich's theories propose that restorative effects of exposure to nature involve physiological and psychological responses (i.e., blood flow, heart rate, hormones) in addition to cultivating environments that require the involuntary attention or fascinations (i.e., gentle moving water, birdsong, or cloud movement). While all the theories are psycho-evolutionary in nature, Stress Recovery Theory is more grounded in physical (voluntary and involuntary) stress reduction responses, while Attention Restoration Theory focuses primarily on psychological (voluntary and involuntary)

responses that promote attention rejuvenation. While the theories have nuanced differences, both focus on exclusively on primarily internal systems and influences on psychological responses.

Diverging from the biological and psychological systems influencing behavior and emotions, the Theory of Planned Behavior (TPB) was a psychological theory promoted by Icek Ajzen in 1991 and built upon the existing Theory of Reasoned Action (TRA) originally proposed by Martin Fishbein and Ajzen in 1975. The Theory of Reasoned Action states that an individual is more likely have greater intention or motivation to perform a certain behavior if they perceive it positively (attitude), and if the action is a subjective norm (others in society want them to perform the behavior) (Ajzen, 1991). TRA was intended as a theory to predict behavior patterns; however, the correlation between behavioral intention and behavioral action often fell short in research. Therefore, Ajzen published TPB with the new aspect of "perceived behavioral control" (Azjen, 1991). Perceived behavioral control is the perception one has of their own ability to perform a given behavior or achieve a specific goal (Azjen, 1991). The addition of this component in the theory indicates that the perceived success of a given action influences whether or not that action will be attempted. Overall, TPB explains behavior as a willful decision based in one's attitude, subjective norms, and perceived behavioral control, which can all vary between individuals, environments, and societies.

Approaching psychological responses and behaviors from an even broader perspective Socio-ecological Theory was popularized in the 1990s and posits that humans are at the center of a complex system wherein their behaviors are influenced by wider socio-economic, cultural, and environmental systems in which they live; essentially individuals' decisions are not solely dependent on individual characteristics or personal responses (Dalhgren and Whitehead, 1991). Additionally, Socio-ecological Theory also differentiates between adults and children,

recognizing that children develop in the context of multiple environments, inside the home, as well as outside the home in the surrounding neighborhoods, schools, and society as a whole (Alderton et al, 2019). Diverging from the psycho-evolutionary theories grounded in biological systems and psychological responses, Socio-ecological Theory offers a more systemic approach to planning and policy.

Overall, the theories strive to explain the driving forces behind the relationship between human beings and their interactions with the environment. Some theories prioritize the internal biological and evolutionary systems behind psychological responses as the driver of behavior. While other theorists explain behavior as a process influenced by social systems, and perceptions of social systems. Each theory can offer insight into the intricate relationship between the built environment and well-being.

4.1.2 Data Sources Listed

Articles could list more than one data source, therefore, approximately 580 data sources were listed in the literature examined (Fig. 4.2). Secondary data, such as Census data or Public Health Surveys, was used 25% of the time. Literature reviews and meta-data processing was used 25% of the time. The third most commonly used data sources at 24% of the time were surveys and interviews. An experimental design was used approximately 15% of the time. Overall, secondary was more commonly used than primary data in the literature

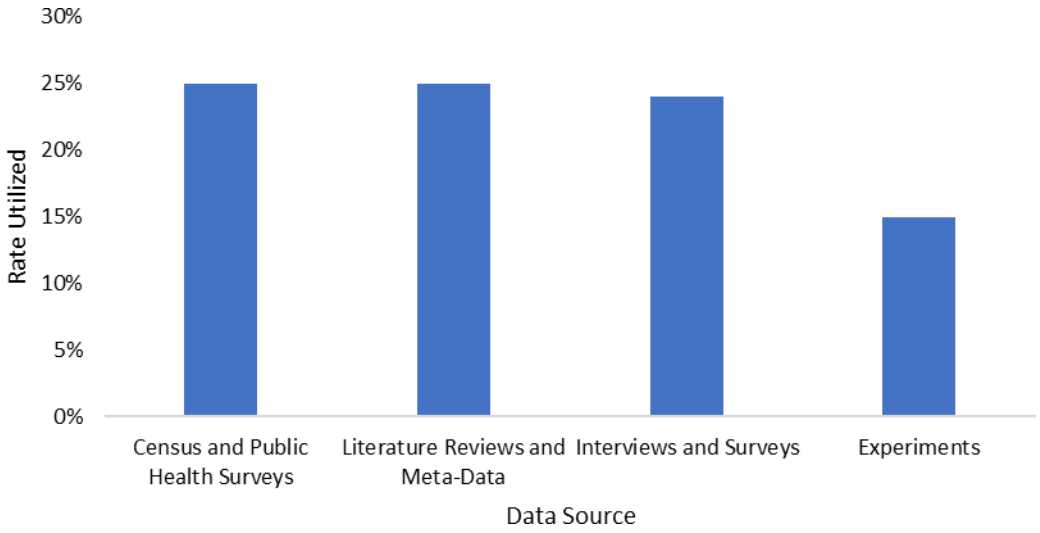


Figure 4.2 The use rate of the data sources listed in the literature examined (n = 580).

4.1.3 Variable Categories

Overall, there were 119 categories identified for over 1400 variables identified in this scoping review of urban greenspace. Variables were extracted from the research questions presented in each study. The extracted variables were then processed into more inclusive categories by topic. The ten most frequently found variable categories in the scoping review, representing 60.4% of all variables extracted, were: Mental Health Outcomes (n = 211), the Built Environment (non-greenspaces) (n = 128), Physical Health Outcomes (n = 128), Access/Exposure/Proximity to Open/Green Space (n = 102), Physical Activity (n = 65), Greenness/blueness (n = 52), Socio-economic and traditional demographics (n = 49), Social Environment (n = 45), Use and/or Visits to Greenspace (n = 36), and Older adults (n = 31, Fig. 4.3).

The largest category was Mental Health and Well-Being, which included variables such as depression, anxiety, ADHD, and stress, and was found in 15% of the papers reviewed. The

second largest categories Physical Health and Well-Being and the Built Environment tied with variables found in 9% of the articles. Used 7% of the time, Access/Exposure/Proximity to Open Space/Green and Blue space was the next most examined variable in the dataset. In approximately 5% of the articles, Physical Activity or Physical Exercise was a primary variable. The Level of Greenness/ Blueness (which is distinct from access to green space and blur space), was used 4% of the time. Socio-demographic characteristics (such as age, gender, income, marital status) and Factors in the Social Environment (i.e. support, cohesion, connectedness, and capital) were each categories of variables used in 3% of the papers reviewed.

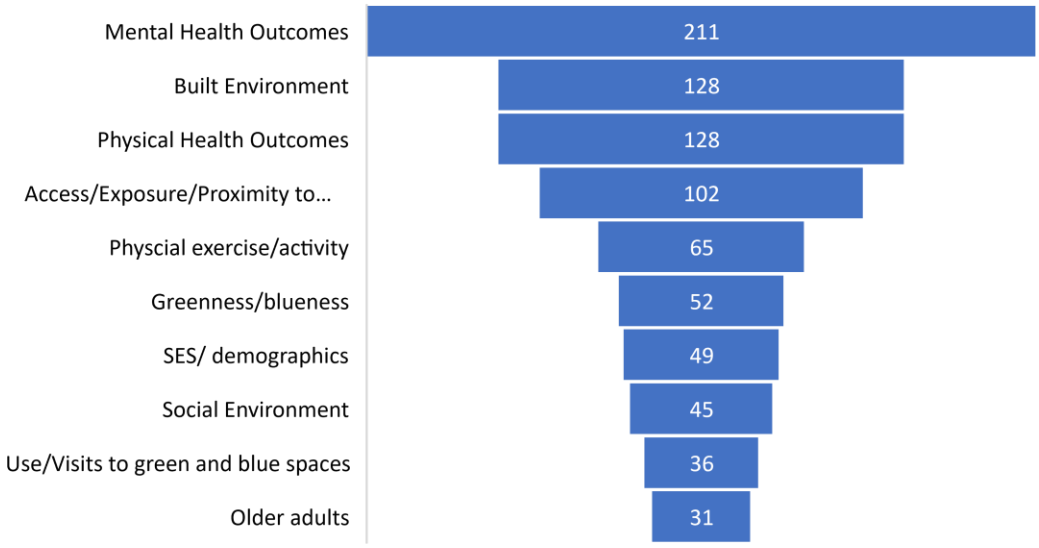


Figure 4.3 The ten most frequent categories of extracted variables by subtopics, and their frequency found in the literature reviewed (n = 847).

4.1.4 Variable Relationships

Overall, there were 21 types of relationships found in this scoping review. The main relationships occur across and between five main topics: Green Space, Mental Health, Physical Health, the Built Environment, and Social Health. The majority (52.6%) of the significant

relationships were positive in nature, indicating that either an increase in one led to an increase or improvement in another or a decrease in one led to a decrease or worsening of another. While negative relationships were only found less than 10% of the time, which was narrowly beaten by inconclusive findings (11.4%), the relationship found most frequently was the one between green space and mental health, representing 34.6% of all relationships found.

Since results could fall within more than one category, the dataset contained a total of 611 results divided into 21 relationships categories (Fig. 4.4). The largest collection of relationships was found between green or blue space and increased mental health (35%). The second largest collection of relationships connected the built environment and mental health (19%). The third largest grouping of relationships connected green or blue space with better physical health (15%). While these results are understandable as they align with the keywords used in the scoping review in general, they show broad relationship groupings and connections between subtopics within the larger field of study.

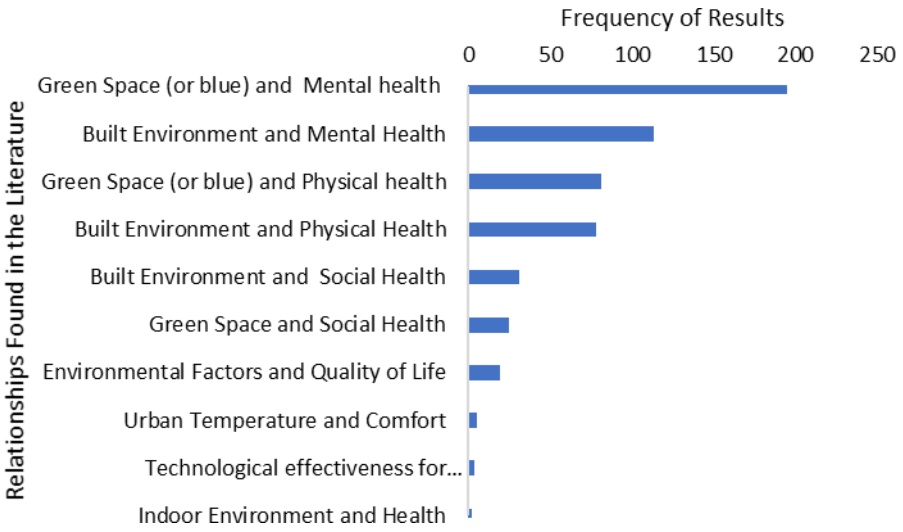


Figure 4.4. Frequency of the 10 most common relationships found in the results of literature reviewed (total number of relationships found = 611).

4.1.5 Common Limitations Found

In the literature examined, 450 articles reported limitations which fell within 10 categories (Fig.4.5). The limitation mentioned most often at 20% were regarding the methodological limitations. The inability to determine causality, reverse causality or the lack of temporal connections came in as the second most mentioned limitation at 15%. In third, at 14%, was the lack of generalizability. Lack of available data and low-quality data was cited in 12% of the articles. Subjective measures in qualitative studies were mentioned in 10% of articles as a limitation. Additionally, confounding variables were listed as a source of limitations in 9% of the papers reviewed. Small sample size, selection and self-selection biases, and search criteria in literature reviews were mentioned in 8% 6%, 4% of papers, respectively. The least mentioned limitation was the use of the Normalized Difference Vegetation Index (NDVI), which is the method of assessing greenness or the density of the green on a patch of land using distinct wavelengths of visible and near-infrared sunlight in satellite imagery.

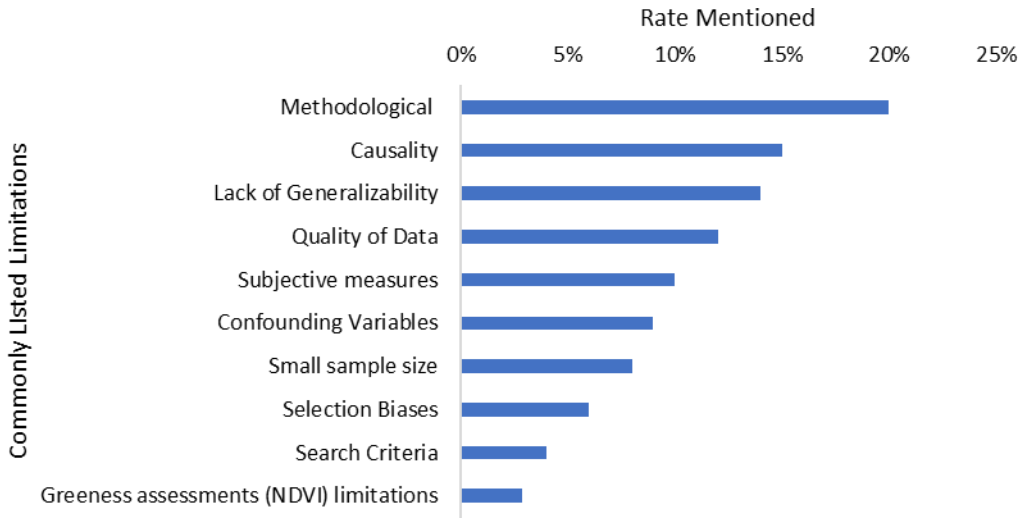


Figure 4.5 The mentioning rate of the limitations found in the literature examined (n = 450).

4.2 Publication Trends

The study period (2010-2021) has seen steady growth in publication trends (Fig. 4.6). Between 2010 and 2015, the average annual number of publications was 24.3. In 2015, the number of annual publications was twice that of the number published in 2010. And between 2016 and 2020, the average annual number of publications was 53.4, quadrupling the number of publications in 2010. The regular growth in the number of publications could be explained by the increasing acknowledgement of the importance of the relationship between urban space and public health. In 1990, President George H. W. Bush declared the "Decade of the Brain," focusing scientific efforts of the National Institute of Mental Health into neurological studies (Walthall, 2020). By 2010, the Mental Health Movement had permeated popular culture, with the National Alliance on Mental Health, an influential mental health advocacy organization, launching a successful mental health awareness campaign using the internet and social media

(Walthall, 2020). The normalization of mental health illnesses and treatments mirrors the increasing rate of publications in this field over the last decade.

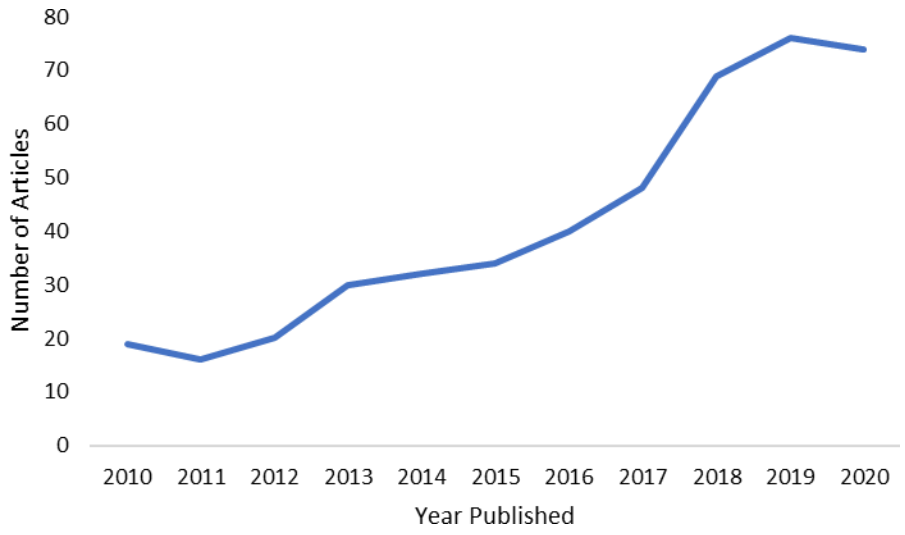


Figure 4.6 Publication trends for 2010-2021. Note the smaller number of articles in 2021 than in 2020 because the literature search was performed in early June of 2021. Overall, the consistent growth trend is expected to continue into 2022.

4.2.1 Journal Publication Trends

Journal	Publication Frequency
International Journal of Environmental Research and Public Health	50
Health and Place	44
Landscape and Urban Planning	30
Urban Forestry & Urban Greening	18
PLoS One	12
Sustainability (Switzerland)	11
Social Science and Medicine	11
Environmental Research	11
Biomedical Central (BMC) Public Health	9
Cities: The International Journal of Urban Policy and Planning	9

Table 4.1. Top 10 journals identified based on their frequency of occurrence in the data set (n= 205).

The papers reviewed were published in 192 distinct journals. The 10 most frequently found journals in the dataset (Table 4.1) represented 41.4% (n= 205) of all articles reviewed (n = 495). Of the most frequently found journals, four are multidisciplinary with an emphasis on environment and public health (International Journal of Environmental Research and Public Health; Health and Place; the Journal of Sustainability; and the Journal of Environmental Research); three are in the field of urban planning (Landscape and Urban Planning; Urban Forestry and Urban Greening; and The International Journal of Urban Policy and Planning); and three are oriented towards medical research (PLoS One; the Journal of Social Science and Medicine; and BMC Public Health). Two primary research areas arise when examining the fields of study of all journals found in the dataset, Health and Environment (Fig. 4.7). Overall, the journals most frequently publishing on the relationship between urban space and mental health are journals in the field of public health, followed by urban planning, healthcare sciences, environmental research, and psychological and psychiatric health (Fig. 4.7).

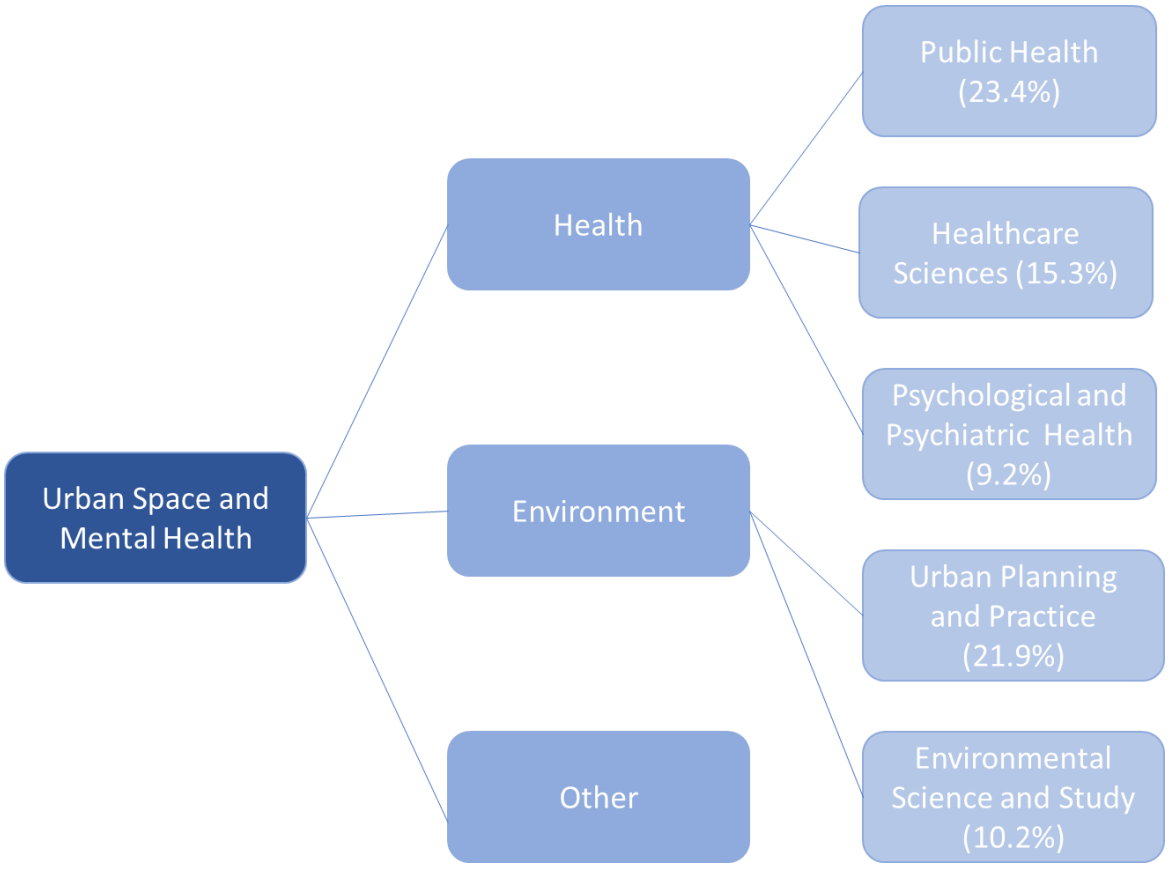


Figure 4.7 Research areas related to urban space and mental health (n =195).

4.2.2 Author Affiliation Trends

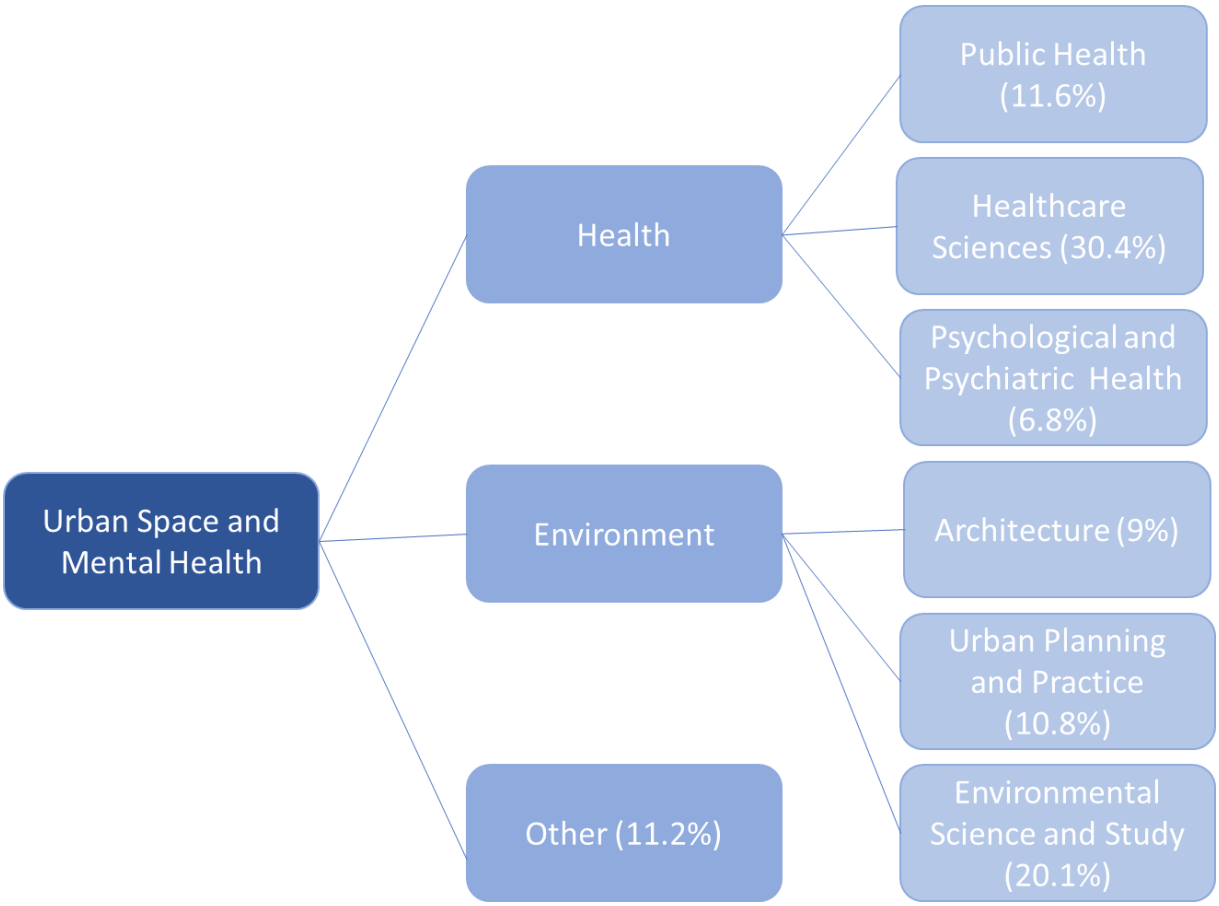


Figure 4.8 Field affiliations of authors in the dataset (n= 500).

The papers reviewed contained 500 distinct author affiliations. Similar to the research fields, the author affiliations could be broadly grouped into Health and Environment, which is unsurprising in light of the original key terms. A third broad category arose, primarily composed of sociology, technology, and public affairs. However, the most prominent author affiliations are in the fields of Healthcare Sciences (30.4%), and Environmental Science and Study (20.1%), followed by Public Health (11.6%) and then Urban Planning (10.8%) (Figure 4.8).

4.3 Keyword Cloud

Using the keywords extracted from the dataset, a keyword cloud was generated to demonstrate frequencies of the keywords in the articles examined (Fig. 4.9; 4.10; 4.11). The larger and darker the words, the higher the frequency of their use. The words with the 10 greatest frequencies were: **health, environment, well-being, neighborhood, green space, exposure factors, stress, activity, mental health, and benefits.** The prevalence of this set of key vocabulary is an indication of the prominence of research into health, well-being, and the environment. In fact, since 2010, nearly 500 relevant articles have been published on the interconnected topic of the influence of the environment on overall health and well-being. When cross-examined with the initial keywords utilized in the literature review, the words that were not searched for, yet rise to the top in frequencies are: **well-being, neighborhood, exposure factors, stress, activity, and benefits**. These terms were not initially sought for, instead they arose in connection with the original search terms and took prominence in the field over the original search terms, indicating a high frequency in the field and a potentially significant relationship with the urban environment, and mental, emotional, and physical health.

By separating the keyword cloud temporally, changes in content can be better visualized (Fig. 4.9; and 4.10). The extracted keywords from 2010-2015 (Fig. 4.9) and the keywords from the second half (Fig. 4.10) of the keyword are nearly identical in composition. Additionally, the most frequent keywords are found not only within both time periods, but also across both (Fig. 4.11). This indicates a remarkable consistency in the composition of the topics over the last decade.

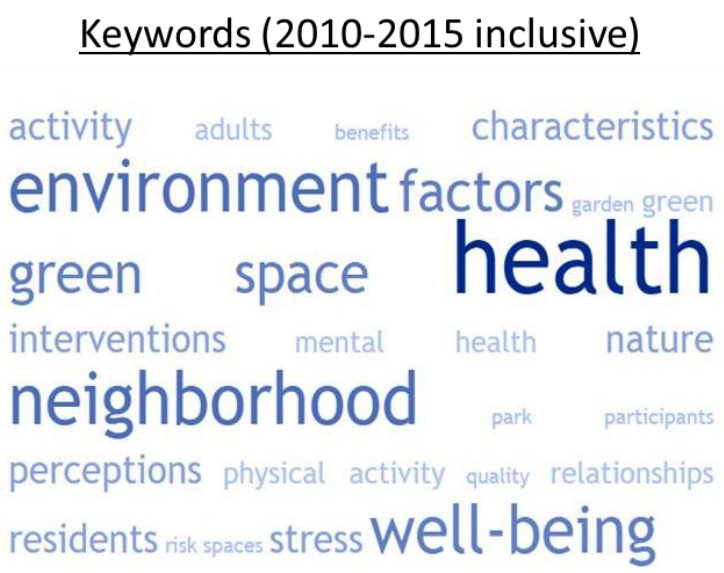


Figure 4.9 Keyword clouds demonstrating the frequency of each keyword and grouping them by similar words. Keywords from all articles between 2010-2015 (n = 25).

Figure 4.10 Keyword clouds demonstrating the frequency of each keyword and grouping them by similarity. Keywords from all articles between 2016-2021 (n = 25).

Figure 4.11 Keyword clouds demonstrating the frequency of each keyword and grouping them by similarity. Keywords from 2010-2021 (n = 25).

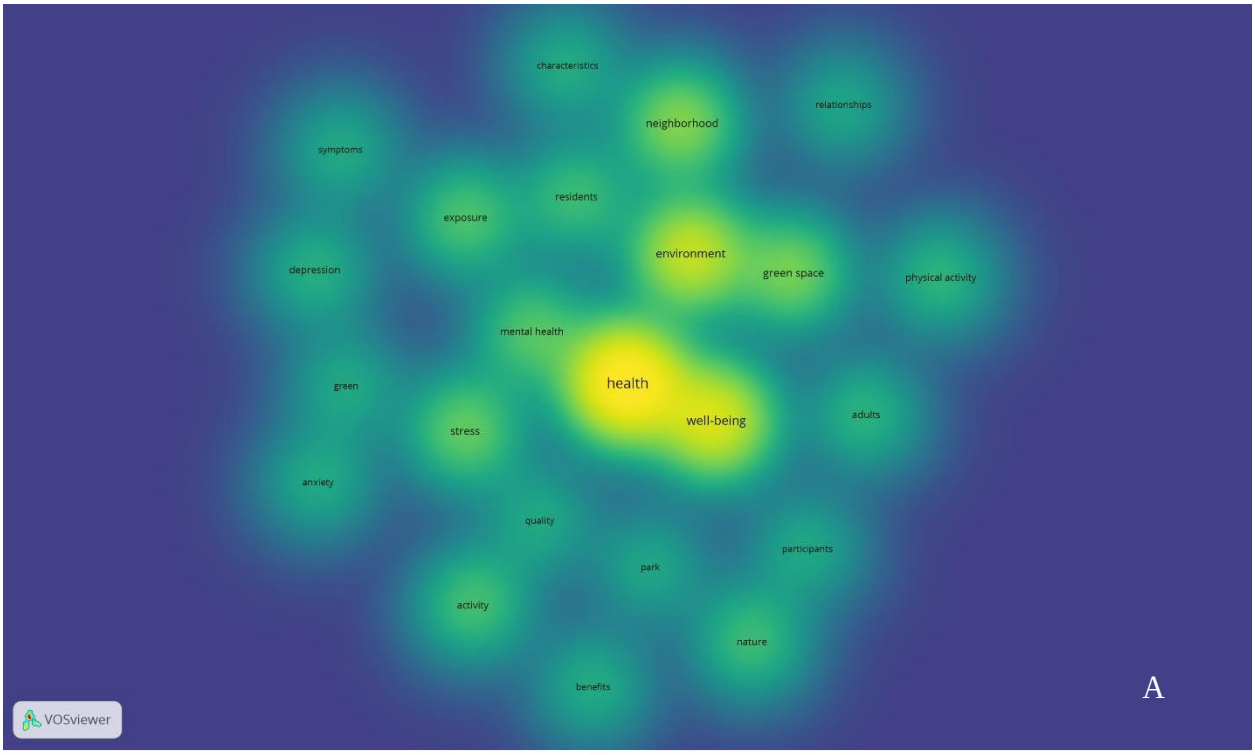
4.4 Bibliometric Analysis

Bibliometric analysis can be used to help determine the significance of the relationships between diverse concepts in the field, such as the ones highlighted in the keyword frequency analysis and relationship frequencies from the scoping review. The bibliometric analysis goes beyond simple frequency and instead examines co-occurrence of terms within the articles themselves, which can offer insight into the strength of the connections between key terms in the research.

4.4.1 Term Co-Occurrence Analysis

Term co-occurrence analysis in the VOSViewer application identified three major thematic clusters. The minimum number of keyword occurrence was set at 20 as trials with a higher number of occurrences led to a cloud with fewer than 20 keywords (which is what the aim was for the cloud) and a lower number of occurrences made the cloud too complex with many additional words in the cloud. This resulted in a total number of keywords of 23 in the keyword cloud (Figure 4.12 A and B). The node size is directly proportional to the frequency of the term and the link thickness indicates link strength (Fig. 4.12 A and B). The density of term co-

occurrence lends itself to three major thematic clusters, which are shown in the three different colors (Figure 4.12 B). Terms that co-occur together more often are clustered together using the different colors (red, blue, and green). The first cluster (red) is the cluster with the highest density, as seen in the density visualization map (Figure 4.12 A and B). The red cluster includes nine terms primarily related to general health, well-being, and activity. Terms such as “health,” “well-being,” “adults,” “park,” “activity,” and “nature,” indicate that there have been numerous studies published on the connection between general health concerns and overall activity levels in the outdoors. However, research that incorporates other influential health factors such epidemiological and sociological considerations, such as social cohesion, are understudied.



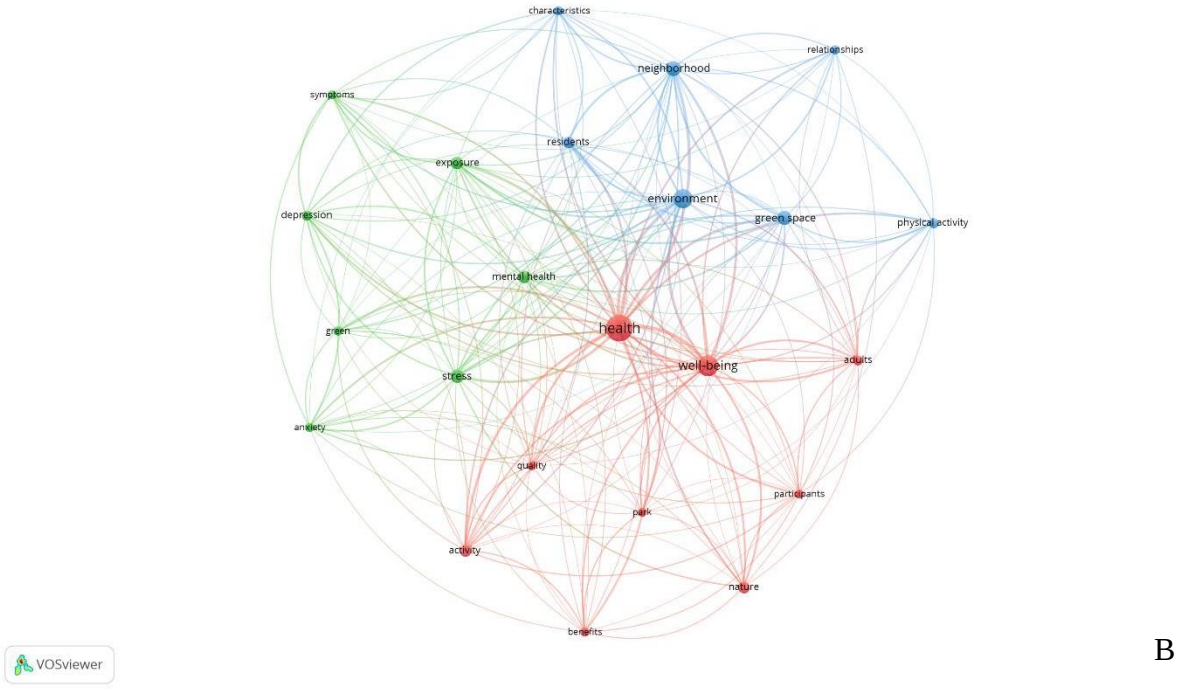


Figure 4.12 A and B. Term co-occurrence map. Node size is proportional to the term frequency and link thickness indicates link strength. Different colors refer to clusters that co-occur frequently.

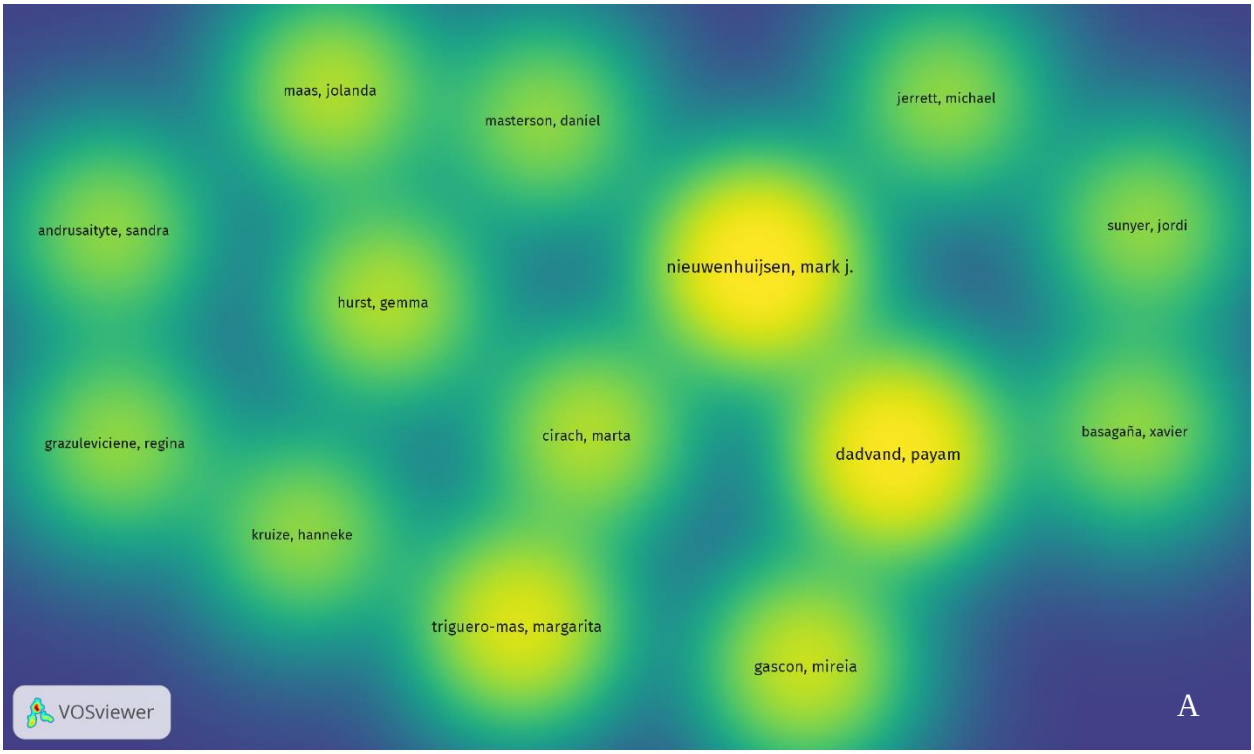
The second most dense cluster (green) includes seven terms primarily related to mental health, stress, anxiety, and depression. Over the last decade, numerous articles have been published on the connection between the built environment, stress, and mental health conditions (Núñez-González, 2020). The presence of "green" and "exposure" in this cluster shows that there has been research into mental health treatments involving increased exposure to greenery and greenness in the environment, as a pathway to address mental health concerns. While the literature focuses on exposure to green areas as a way to treat mental health, there is little research into exposure to green areas as a preventative care for mental health.

The final cluster (blue) includes six terms. The thematic focus of this cluster is primarily related to the environment, both built and natural, green space, and physical activity. The blue cluster is comparatively the weakest thematic grouping, indicating that the terms are less popular relatively to the other thematic clusters. However, the prevalence of terms like "neighborhoods" and "environment" combined with the comparatively lower ranking of "green space," indicates that the literature has focused more so on measuring and assessing the built environment's impact on residents rather than urban green spaces, when considering the relationship between well-being and urban space.

Given the linkages between the terms "health," "green space," "mental health," and "environment," it is clear that many studies have been published on the connection between mental health and the natural environment. Other important mental health-related topics connected to green space usage are understudied, like neurological impacts, cognitive development, and emotional and social health.

4.4.2 Influential Authors

The second bibliometric analysis identifies the authors who have been the most influential in this field (Figure 4.13 A and B, Table 4.2). This was done using citation analysis, which ranks the authors based on the citation data of the retrieved articles. The minimum number of documents for an author to be considered was set at four articles in order to generate a sufficient number of connections to visualize (Table 4.2, n = 24). Table 4.2 ranks the frequency of authorship and link strength for each author, these are visualized in the bibliometric analysis by vividness of color, and number and thickness of the connecting lines (Figure 4.13 A and B). The link strength is a measure of internal connectedness rather than simple frequency of authorship and indicates how often authors co-authored with other authors in the dataset (Table 4.2). The top 10 authors who have been co-cited often are: Mark J. Nieuwenhuijsen, Margarita Triguero-Mas, Payam Dadvand, Marta Cirach, Gemma Hurst, Jolanda Maas, Hanneke Kruize, Daniel Masterson, Xavier Basagaña, and Sandra Andrusaityte (Table 4.2). Additionally, Figure 4.13A shows clusters of authors who have frequently worked together on similar topics. The color of the linkages indicates authors that work on similar thematic focuses. For instance, Mark Nieuwenhuijsen and Payam Dadvand are both prominent scholars in the field of cognitive development and exposure to urban green space and both are located in the green cluster. The red cluster connects prominent researchers in the fields of public health and life sciences, like Marargita Triguero-Mas and Gemma Hurst.



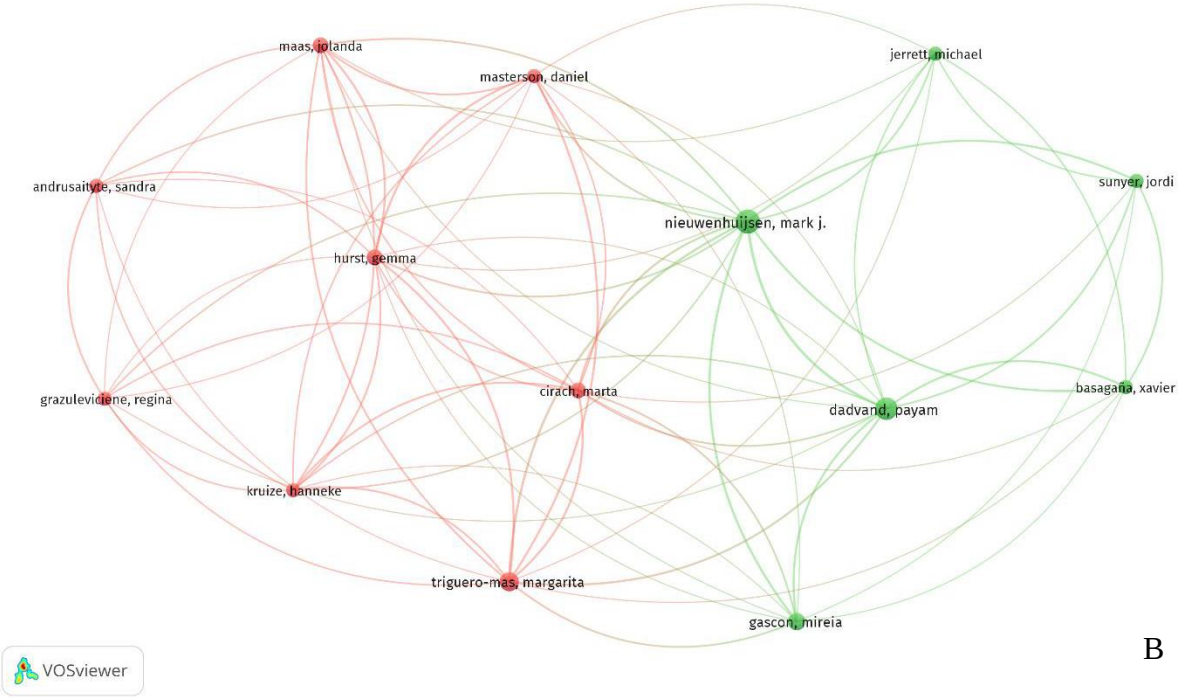


Figure 4.13 A and B. The most influential authors based on the co-citation analysis.

Author	Documents	Link Strength
Mark J. Nieuwenhuijsen	11	47
Margarita Triguero-Mas	7	36
Payam Dadvand	10	33
Marta Cirach	5	28
Gemma Hurst	5	28
Jolanda Maas	5	25
Hanneke Kruize	4	24
Daniel Masterson	4	24
Mireia Gascon	6	22
Xavier Basagaña	4	16
Sandra Andrusaityte	4	15
Regina Grazuleviciene	4	15
Jordi Sunyer	4	14
Micheal Jerrett	4	13
Richard Mitchell	8	9
Peter Aspinall	4	7
Jenny Roe	5	7
Catharine Ward Thompson	4	6
Terry Hartig	7	5
Thomas Astell-Burt	4	4
Billie Giles-Corti	9	0
Marco Helbich	4	0
Viniece Jennings	4	0

Table 4.2 Top 23 authors identified based on their frequency of occurrence in the data set, and their link strength with co-authors also in the dataset.

CHAPTER 5. DISCUSSION

Overall, this study found that the relationship between mental health and the urban environment is most often examined through the lens of urban green space and stress reduction. Whereas the connection between the general health and the urban environment is more often examined through the perspective of physical activity and the built environment. As mental health and well-being continues to increase in importance and prominence in the public, considerations regarding how protect and promote mental health through the urban environment, both built and natural, requires attention. This issue has been consistently examined and is well-recognized in the scientific and policy realms, as demonstrated by the numerous articles and frameworks published that provide solutions to enhance access and quality of urban environments for the purposes of increasing public health and well-being. The primary objective of this study was to create a better understanding of the existing knowledge and trends in the literature regarding the relationship between the built environment and mental health. To accomplish this, journal articles, documents, keywords, and authors were identified that are influential in the progression of this topic. Bibliometric analysis and science mapping applications allowed for performance analysis and knowledge domain visualization. Uniquely, this study drew 495 articles from four distinct journal databases, whereas traditional bibliometric analyses draw from a single source. By drawing from a broader base of knowledge, this study offers a more holistic view of the trends in the field of research on the connection between urban environments and well-being to better identify future research pathways.

5.1 Implications for Research

This study examined the state of the literature in order to better understand the relationship between urban spaces and mental health. The results indicate that there was existing

interest in this field, with the annual publications having increased steadily since 2010. The growth rate has been consistent, but the publication rate has been particularly high over the last five years, indicating that there has been an increasing focus on the importance of the impacts of urban space on human well-being and mental health. When the literature is examined, the variables in the papers reviewed underscore the relationships between mental health, well-being, and the built environment through the lenses of psycho-evolutionary theories. Attention Restoration Theory and Stress Recovery Theory are prominent theories wielded by researchers to understand the relationships between the built environment and mental health. Psycho-evolutionary theories strive to explain psychological processes like emotions, mental health, and well-being through an approach grounded in evolution and biological explanations.

In general, most of the papers reviewed found positive relationships between green or blue space and mental health. Through keyword frequency analysis, relationships between the original search terms and key concepts in the field were highlighted and visualized, particularly concepts such as well-being, neighborhood, exposure, stress, activity, and benefits. The strength and nature of these relationships in the field were further illustrated by bibliometric analysis where several focus areas were identified. However, it is important to note that there has been a steady composition of topics in the field over the last decade, which could indicate stagnation and a need for diversification in research approaches.

Examining the prominent journals publishing on this topic highlights diverse perspectives to approaching this research topic and underscores the complex nature of the relationship between mental health and urban environments. Analysis showed that the most prolific journals on this topic were from the field of public health, followed by the field of urban planning. Regarding the affiliations of the publishing authors, there is a lack of urban planners in this field

as our examination showed that healthcare and environmental scientists are the most prolific on this topic.

The prominent thematic cluster focused on health and well-being, with an emphasis on physical activity. Physical activity was not an original search term. The strength of the relationship between health, the urban environment, and physical activity is underscored by the extensive existing research performed in the field. The positive relationship between physical activity and physical health has been well-established as increased physical activity has been shown to increase overall health factors, and accessible urban environments have been shown to increase passive physical activity such as walking (Orstad et al., 2017). Furthermore, physical activity is a readily quantifiable factor which is typically measured either in frequency of visits to parks or in amount of time spent exercising. The strong relationship found between these terms in the literature indicates that when examining the relationship between the urban environment and general health, physical activity rises to prominence as the lens through which the majority of the field examines health.

Another major thematic area is focused on mental health and associated conditions such as anxiety and depression. As urbanization increases, mental disorders have been found to increase proportionately as social support networks decrease (Desjarlais et al., 1995), and impoverished people have been known to experience environmental and psychological adversities that increase vulnerability to mental disorders (Patel, 2001; Srivastava, 2009). Additionally, in 2016, mental disorders affected more than 1 billion people globally, causing 7% of the global burden of disease as measured in disability-adjusted years (DALYs) (Rehm and Shield, 2019). Likely, as mental health becomes less culturally taboo in Western countries and

treatment and awareness become more commonplace, these studies will continue to rise in frequency and potentially influence policymakers (Walthall, 2020).

The third, and final, thematic grouping is concerned with the environment, both built and natural. As seen in the bibliometric analysis, green space and mental health are strongly connected and located near to each other in the visualization. Even though green space was an original search term, when examining the relationship between the urban environment and mental health, green space is often prominent. Influenced by the prominent psycho-evolutionary theories of Stress Reduction Theory and Attention Restoration Theory, green space and mental health have been well-connected in the literature. Unlike physical activity, mental health factors can be more difficult to target and assess. However, Stress Reduction Theory is built on the functioning of the endocrine system in the body (a system of gland and organs that use hormones to coordinate and control the body's metabolism), experiments measuring the connection between green space exposure and stress often measure physical salivary cortisol levels (Roe et al, 2013; Jiang et al., 2014; Triguero-Mas et al., 2017; Mygind et al., 2021). On the other hand, Attention Restoration Theory relies on cognitive measurements, such as EEGs to measure brain activity, cognitive testing, and/ or mood assessments (Han et al., 2021; Mennis et al., 2018; Lin et al, 2020). Urban environments include both the built and natural, and the results from this study indicate that the literature between mental health and urban spaces is primarily concerned with the natural environment rather than the built.

Overall, these thematic groups cover issues related to three main factors mitigating the relationship between urban spaces and well-being: general health, mental health, and environmental conditions. However, assessing other important, yet less tangible, contributing factors to health, such as community, social cohesion, and emotion has, comparatively, been

understudied. Further research on assessing the social and emotional dimensions of well-being and green space should be performed. Additionally, the fact that the clusters are very distinct thematically, indicates that there is a lack of interdisciplinary approaches to understanding the intricate and complex factors contributing to the relationships between health, well-being, and urban green spaces. Future interdisciplinary research examining interrelated physical, psychological, and social health factors would advance the field.

5.2 Implications for Practice

While the relationship between urban green spaces and mental health have been well-studied, urban green spaces compose a minority of the landscapes in urban areas. While utilizing urban green space is beneficial, the quotidian urban environments should be examined for their relationship to mental health. Designing and planning cities that are protective against mental illnesses should not only be limited to creating pockets of calm areas which often result in socioeconomic disparities and injustices, but instead researchers can examine mechanisms and processes that make the larger built environment more beneficial to mental health overall.

As the field of urban planning lends itself to interdisciplinary research and has a significant stake in designing and planning urban environments, both built and natural, urban planning researchers are poised to examine this relationship more deeply in the near future. Furthermore, as was seen in the Healthy Cities Movement, translating research into practice and policy can remain an obstacle even with well-researched and established connections between health and urban environments. Outside of research, urban planners are uniquely positioned to facilitate the transition of research into implementation through education and advocacy.

In addition, the COVID-19 pandemic has exacerbated underlying issues, such as mental health; and, brought new light and prominence to urban green spaces as one of the few

components of our cities that were the least negatively impacted by community shutdowns and restrictions (Korpilo et al., 2021). More research on how implementing urban green spaces can make communities' more resilient through buffering physical health concerns and shoring up mental health protections, should be conducted in the future.

5.3 Methodological Implications

Beyond topics of future research, this study has the potential to provide practical benefits to the methodologies of academic study in the field of urban planning. The primary method of analysis for this study was a bibliometric analysis of the field of knowledge. This form of analysis has great potential to change the traditional methods of academic study. As an interdisciplinary field by nature, assessing a given urban planning topic thoroughly can be arduous and prone to myopic views of the literature. With bibliometric analysis, students and researchers can better access the field of study from a holistic perspective. The addition of a bibliometric analysis to a standard literature review requires only that the researcher collect and manager their digital journal articles in an article database manager that can generate compatible files (i.e. RIS) to run through a software, like VosViewer, in order to generate the bibliometric analysis for interpretation. Identifying link strength amongst terms can reveal connections amongst research areas in the field. Generating density visualizations of terms can assist in pinpointing gaps in the literature. And locating thematic clusters can highlight relationships amongst topics in the field of study. All of these characteristics can assist researchers in moving forward with future research confident in their prior knowledge of the field.

5.4 Strengths and Limitations

This study evaluated the available and relevant knowledge base of the relationship between urban spaces and well-being, both physical and psychological. The search only spanned

the publication years (2010-2021), as there is a wide publication base. Additionally, a search filter was applied. To limit bias in the data selection and extraction, keyword extraction software was applied to all articles, even if they provided their own keywords. Publications were limited to those published in English, which may have resulted in some studies having been missed. This study was limited by the broad scope of the topic at hand, for instance, "the built environment" can range from buildings to neighborhood characteristics, to expansive outdoor areas either urban or rural. As such, the search was not limited to specific types of green spaces, environment types, or well-being varieties, instead it measured the interactions on a broader level. Finally, this study incorporates articles from several scientific databases, which is rare and limited the forms of bibliometric analyses that could be performed but offers a more complete overview of the status of the literature.

5.5 Conclusions

Beyond thematic identification, this study underscores key authors and publication trends. Uniquely, this study sourced journal articles from multiple databases, which provides a well-rounded view of the current knowledge structure. Overall, this study has provided a better understanding of contemporary research trends on the urban environment and health, both physical and psychological, in a growing field. Further examination of existing gaps in the field is needed to provide a more detailed grasp of the intricate social, emotional, physical, and psychological factors influencing well-being when exposed to urban green space. Finally, future research should make efforts to increase interdisciplinary approaches, reduce reliance on cross-sectional data and incorporate study methods that allow for more causation to be deduced to address the existing knowledge gaps.

APPENDICES

APPENDIX A: Theories found in the literature

Theory	Number of Times Used	Percentage of total
Attention Restoration Theory	74	26.7%
Stress Reduction Theory	37	13.4%
psycho-evolutionary theory	7	2.5%
Appleton's prospect-refuge theory	6	2.2%
Environmental Restorative theory	6	2.2%
Socio-ecological theory	6	2.2%
Theory of Planned Behavior	6	2.2%
Biophilia hypothesis	5	1.8%
Activity Theory	4	1.4%
Broken Window Theory	4	1.4%
Lawton and Nahemow's Ecological Theory of Aging	4	1.4%
Self-Determination Theory	4	1.4%
Spatial Experience	4	1.4%
Social Cognitive Theory	3	1.1%
social theory	3	1.1%
Space syntax theory	3	1.1%
attachment theory	2	0.7%
Behavioral Change Theory	2	0.7%
Circumplex theory of affect	2	0.7%
Developmental Theory	2	0.7%
Ecological Theory	2	0.7%
Heat Balance Theory	2	0.7%
Place Theory	2	0.7%
Social Capital Theory	2	0.7%
Social Interaction Theory	2	0.7%
Theory of natural movement	2	0.7%
Materialist Theory of Becoming	1	0.4%
adaptive comfort principles/approaches	1	0.4%
affordance theory	1	0.4%
architecture theory,	1	0.4%
basic psychological needs theory	1	0.4%
Biopsychological emotion theory	1	0.4%
Bronfenbrenner's framework	1	0.4%
cognitive architecture theory	1	0.4%

Table A.1 All theories found in the literature reviewed (n=277).

Table A.1 (cont'd)

Theory	Number of Times Used	Percentage of total
Cognitive Dissonance Theory	1	0.4%
Cognitive Map theory	1	0.4%
cognitive-experiential self-theory	1	0.4%
Color Theory	1	0.4%
consonant with continuity theory	1	0.4%
core social motives theory	1	0.4%
critical race theory	1	0.4%
Csikszentmihalyi's Theory of Flow	1	0.4%
Cultural Attachment Theory	1	0.4%
Distinctive Theory	1	0.4%
Effort-recovery Model	1	0.4%
Environmental Economics Theory	1	0.4%
Environmental Health Theory	1	0.4%
Feminist Disability Theory of Urban Design	1	0.4%
Fuzzy Knowledge Base (FKB)	1	0.4%
Gessler's Concept of Therapeutic Landscapes	1	0.4%
Gestalt Theory, Gibson's Theory	1	0.4%
Gibson's Theory of Ecological Preservation	1	0.4%
Glass and Singer's Theory of Emotion	1	0.4%
Health Inequities Theory	1	0.4%
Humphrey's Theory	1	0.4%
Johnson-Laird's Theory	1	0.4%
Life course Theory	1	0.4%
Model of the Role of Parks in Public Health	1	0.4%
Motivation Theory	1	0.4%
Nature-affinity Theory	1	0.4%
New Urbanist Theory	1	0.4%
Operative Learning Theory	1	0.4%
Opponent Process theory	1	0.4%
Opportunity Theory	1	0.4%
architecture theory,	1	0.4%
basic psychological needs theory	1	0.4%
Biopsychological emotion theory	1	0.4%
Bronfenbrenner's framework	1	0.4%
cognitive architecture theory	1	0.4%
Cognitive Dissonance Theory	1	0.4%
Perception-based theory	1	0.4%

Person-Environment Fit-theory	1	0.4%
Positivist Theory	1	0.4%
Psychological sense of community (PSOC) theory	1	0.4%
Public Good Theory	1	0.4%
Resilience and Empowerment Theory	1	0.4%
Selective migration theory	1	0.4%
Selective Optimization with Compensation (SOC)	1	0.4%
Set Point Theory	1	0.4%
Social communication space theory	1	0.4%
Social disorganization theory	1	0.4%
Social Drift Theory	1	0.4%
Social provisions theory	1	0.4%
Socio-environmental justice theories.	1	0.4%
Sociological and community psychology theory	1	0.4%
Spatial communication theory	1	0.4%
Spatial Polygamy Theory	1	0.4%
Subjective Wellbeing Homeostasis Theory	1	0.4%
Supportive Environment Theory	1	0.4%
Sustainability Through Happiness Framework	1	0.4%
Terror management theory	1	0.4%
The evolutionary theory of aesthetics	1	0.4%
The habitat theory	1	0.4%
The savanna hypothesis	1	0.4%
Theoretical model of Campbell, Converse, and Rodgers	1	0.4%
Theories of structural confounding	1	0.4%
Theory of community mapping	1	0.4%
Theory of environmental stress	1	0.4%
Theory of expected value of control	1	0.4%
theory of GeoParticipation	1	0.4%
Theory of legibility	1	0.4%
theory of loose parts	1	0.4%
theory of personhood in dementia	1	0.4%

Table A.1 (cont'd)

Table A.1 (cont'd)

Theory	Number of Times Used	Percentage of total
Theory of Reasoned Action	1	0.4%
Theory of Spatial Learning	1	0.4%
Theory of Wholeness	1	0.4%
Urban design theory	1	0.4%
Virtual Restorative Environment Therapy	1	0.4%
Washburne's Theory	1	0.4%
William James's theory of attention	1	0.4%
Total	277	100.0%

APPENDIX B. Variables found in the literature

Variables	Number of Times Used	Percentage of Total
Mental Health Outcomes (depression, anxiety, ADHD, stress etc), mental well-being	211	15.0%
Built Environment	128	9.1%
Physical Health Outcomes/ Physical well-being	128	9.1%
Access/Exposure/Proximity to Open Space/nature (green and blue space)	102	7.3%
Physical exercise/activity	65	4.6%
Greenness/blueness (residential, urban)	52	3.7%
SES/ demographics (age, sex, gender, income, marital status etc)	49	3.5%
Social Environment (support, cohesion, connectedness, capital)	45	3.2%
Use/Visits to green and blue spaces	36	2.6%
Older adults	31	2.2%
Neighborhood characteristics (safety, disorder, service quality, linking, appearance etc)	29	2.1%
Gardening/Gardens	26	1.9%
Time comparison (pre-post development intervention)	24	1.7%
Respite/Restoration/Stress Reduction	23	1.6%
Children	21	1.5%
Perceived physical environment	21	1.5%
Cognitive function	17	1.2%
Social Health	17	1.2%
Noise Pollution	16	1.1%
Walkability	16	1.1%
Natural Environment	15	1.1%
Walking behavior	15	1.1%
Air pollution	14	1.0%
Emotional Response	14	1.0%
Neural activity	13	0.9%
Geospatial factors	11	0.8%
Quality of green space	10	0.7%
Dementia patients	9	0.6%
Quality of life	9	0.6%
Teenagers	9	0.6%

Table B.1 All variables found in the literature reviewed (n = 1402).

Table B.1 (cont'd)

Variables	Number of Times Used	Percentage of Total
Physical Stress Responses	8	0.6%
Attitude toward nature	7	0.5%
Impact on people with disabilities	7	0.5%
National and Local public planning policies	7	0.5%
Therapeutic interventions	7	0.5%
Mobility	6	0.4%
Perception of temperature	6	0.4%
Perception of threat (safety)	6	0.4%
Perceived neighborhood characteristics	6	0.4%
Risk of Death/Mortality/Morbidity/Life expectancy	6	0.4%
Tree cover	6	0.4%
Happiness/positive moods/feelings	5	0.4%
Housing	5	0.4%
Population Density	5	0.4%
Urban/Rural	5	0.4%
Women	5	0.4%
Climate data	4	0.3%
Health recovery length	4	0.3%
Light pollution	4	0.3%
Place Attachment/ sense of place	4	0.3%
Psychological needs satisfaction (autonomy, competence, relatedness)	4	0.3%
Quality of public space	4	0.3%
Active Transportation/Neighborhood Based Transport	3	0.2%
Behavioral problems/issues	3	0.2%
Biodiversity in natural environments	3	0.2%
Child Development	3	0.2%
Climate Change	3	0.2%
Cognitive Maps	3	0.2%
Leisure activities in parks	3	0.2%
Light exposure	3	0.2%
Perceived accessibility of the neighborhood	3	0.2%
Sedentary behavior	3	0.2%
African Americans	2	0.1%
Attitude toward walking	2	0.1%
COVID restrictions	2	0.1%
Cultural Ecosystem Services	2	0.1%

Table B.1 (cont'd)

Variables	Number of Times Used	Percentage of Total
Effectiveness of wearable technology	2	0.1%
Eye movements (interest) (combined with neural activity?)	2	0.1%
Feelings of trust	2	0.1%
Healthcare	2	0.1%
High density urban areas (crowds)	2	0.1%
Home Design	2	0.1%
Nature Relatedness/Connectedness	2	0.1%
Number of falls	2	0.1%
Place Identity	2	0.1%
Proximity to Park/green space	2	0.1%
Public Health	2	0.1%
Street Proximity	2	0.1%
Vacant land	2	0.1%
Virtual exposure	2	0.1%
Functional characteristics of space	1	0.1%
Incremental cost-effectiveness ratios	1	0.1%
Intangible and sensory characteristics of space (S).	1	0.1%
Aging in Place	1	0.1%
Aesthetic Values	1	0.1%
Behavioral Development	1	0.1%
Benefits of Urban parks	1	0.1%
Birth weight	1	0.1%
collection and visualization of emotion based and subjective information on maps	1	0.1%
Diet	1	0.1%
Drug and alcohol consumption	1	0.1%
Economic impact	1	0.1%
Effectiveness of worksite social and physical environment on need for recovery (work-related mental and physical fatigue)	1	0.1%
Electrodermal activity	1	0.1%
Emotional attachment to local green space	1	0.1%
Empowerment	1	0.1%
Environmental annoyance	1	0.1%
Facilities at places of worship	1	0.1%
Food Security	1	0.1%
Gestational Age at Delivery	1	0.1%

Table B.1 (cont'd)

Variables	Number of Times Used	Percentage of Total
Green Gentrification	1	0.1%
Hazardous Waste Infrastructure	1	0.1%
Hospital admissions	1	0.1%
Impervious surfaces (quantity)	1	0.1%
Implications of exposure to immunoregulation-inducing microorganisms in urban environments	1	0.1%
Nutrition Behavior	1	0.1%
Oppressiveness of streetscapes	1	0.1%
Participatory Urban Planning	1	0.1%
Perceptions of neighborhood wealth	1	0.1%
Psychiatric patients in a neighborhood	1	0.1%
Quality-adjusted life-years	1	0.1%
Schoolyard greening	1	0.1%
Secondhand smoke	1	0.1%
Sleep duration/ quality	1	0.1%
Smoking/non-smoking status	1	0.1%
Stress recovery process	1	0.1%
Urban Sprawl (population density, net residential density, coverage ratio, land use types, percentage of residential land use, and average year of construction)	1	0.1%
Words/terms in articles in Health and Place between 1995 and 2018	1	0.1%
Work/life spillover	1	0.1%
Total	1402	100.0%

APPENDIX C. Data sources listed in the literature

Data Source Type	Number of Instances	Percentage of total
Survey Data (non-original data, often of large populations ie. Census data, public health surveys either national or state)	145	25.0%
Literature Review (non-original data, meta-data processing)	143	24.7%
Questionnaire (original data, non-survey)	98	16.9%
Experiment (original data, quantitative, non-questionnaire)	87	15.0%
Interviews (original data, qualitative, non-survey)	43	7.4%
Mixed_Q_Q	22	3.8%
Focus Groups (original data,	10	1.7%
Mixed_Qualitative	10	1.7%
Qualitative	9	1.6%
Protocols/Recs	7	1.2%
Mixed_Quantitative	6	1.0%
Total (the number is larger than the number of articles as articles could have multiple data source types)	**580**	**100.0%**

Table C.1 All data sources listed in the literature reviewed (n = 580).

APPENDIX D. Analytical methods utilized in the literature

Analysis Types	Number of Instances	Percentage of Use
Regressions	181	27.6%
Reviews - Systematic/Scoping	103	15.7%
Descriptive/Inferential Stats	60	9.2%
Thematic coding and analysis	36	5.5%
GIS/Spatial Analyses	35	5.3%
ANOVA/ANCOVA/MANOVA/MANCOVA/Kruskal-Wallis/Mann-Whitney	34	5.2%
Qualitative	27	4.1%
Correlation	24	3.7%
Factor Analysis	22	3.4%
Mediation analysis	21	3.2%
Chi-square/T-Tests	21	3.2%
Mixed effects modeling	13	2.0%
SEM	12	1.8%
Poisson	7	1.1%
Fixed effects/Random Effects	6	0.9%
Sensitivity analysis	5	0.8%
Cognitive testing (Stroop)	5	0.8%
Multilevel random intercept model	4	0.6%
Content analysis	4	0.6%
Posthoc analysis	4	0.6%
Analytic hierarchy	4	0.6%
Meta Analysis	4	0.6%
Constant comparative	3	0.5%
Generalized additive mixed models GAMM	3	0.5%
Wilcoxon signed rank	3	0.5%
Cox Proportional Hazards	3	0.5%
Visual Integration	3	0.5%
Decision trees	2	0.3%
Realist Analysis	2	0.3%
Proforma analysis	2	0.3%
Discrete Choice Modeling	1	0.2%
Q-Method	1	0.2%
Total	655	100.0%

Table D.1 All analytical methods utilized in the literature reviewed (n = 655).

APPENDIX E. Relationships found in the literature

Main Result Relationships	Number of times used	Percentages
Green space (or blue) has a relationship with mental health	195	34.6%
Built Environment has a relationship with Mental Health	113	20.0%
Green Space (or blue) has a relationship with Physical health	81	14.4%
Built Environment has a relationship with Physical Health	78	13.8%
Built Environment has a relationship with Social Health	31	5.5%
Green space has a relationship with Social Health	25	4.4%
Environmental factors have a relationship with Quality of Life	19	3.4%
Urban temperature has a relationship with Comfort	5	0.9%
Technological effectiveness for measuring urban interactions	4	0.7%
N/A Indoor Env and Health	2	0.4%
Built Environment has a relationship with Children's autonomy	1	0.2%
Built Environment has a relationship with Economic impact	1	0.2%
COVID impacts/restrictions	1	0.2%
Culture/ well-being	1	0.2%
Lighting types has a relationship with Emotional responses	1	0.2%
Memory/mapping	1	0.2%
Perceptions of pollution (air and noise) has a relationship with actual pollution (air and noise)	1	0.2%
Physical Activity has a relationship with Mental Health	1	0.2%
Physical Activity has a relationship with Social Health	1	0.2%
Physical impairment has a relationship with physical activity	1	0.2%
Social Environment has a relationship with Mental Health	1	0.2%
Total	**564**	**100.0%**

Table E.1 All relationships found in the results in the literature reviewed (n = 564).

APPENDIX F. Limitations found in the literature

Limitation Type	Number of Instances	Percentage
Methodological limitations	148	19.6%
Causality cannot be assumed (lacking temporal connection)	114	15.1%
Generalizability	102	13.5%
Quality of the data gathered (incl. missing variables)	90	11.9%
Subjective measurements (self-reported, observational etc.)	75	9.9%
Confounding variables	71	9.4%
Sample Size	57	7.6%
Selection/Self-selection bias	44	5.8%
Gaps in Lit OR Review parameters used	31	4.1%
NDVI does not differentiate between types of greenness/ greenness type not specified/ vague green measurements	22	2.9%
Total	**754**	**100.0%**

Table F.1 All limitations listed in the literature reviewed (n = 754).

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