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**The Impact of Environmental Characteristics on**

**Public Health: A Systematic Review and Meta-analysis**

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# The Impact of Environmental Characteristics on Public Health: A Systematic Review and Meta-analysis

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## ABSTRACT

**Introduction:** A health-social-environment ecosystem is proposed to engage deeply within communities and to better understand social-environmental influences of health (Quek, 2022). In terms of deeply analysing the multi-faceted connections between built environment and human health, summarizing multiple environmental characteristics, and determining how they contribute to the health outcomes is necessary. Despite some studies investigating about the relationship between the two factors in certain regions, there are few studies about this topic in a worldwide context or analysing the current research gap for further related studies. Our study aimed to undertake a systematic review to find the evidence on the relationship between built environment characteristics with public health, and to analyse the potential research trends and gaps for further related studies.

**Methods:** We searched 3 databases to review research journals, that are associated with certain environmental variables and public health, published from 2013 to 2023. Over 20,000 studies were reviewed in the study, and relevant studies were synthesised in relation to their research methods, study sample, region, environmental variables and public health outcomes.

**Results:** Our systematic review looked into the relationships between environmental variables ("Green Space", "Fast-Food Density", "Health Facilities Number", "Population Density, "Built Density", "Land Use Diversity", "Streets Connectivity", "Access to Public Transport", "Access to Social Facilities", "Access to Recreational Facilities/Entertainment Attractions)", "Aesthetics" and "Safety") and public health (obesity, blood pressure, mental health, chronic diseases, cardiovascular disease, diabetes, infectious disease, physical health, etc.).

**Conclusion:** The relationship between green space and public health factors (including mental health, physical health and self-rated health) is significant. Despite some studies focusing on different age groups reported non-significant or negative relationship, most of them reported a positive correlation between greenness and public health. Other environmental variables like fast-food restaurant density, land use diversity, and street connectivity are positively associated with public health factors. However, further evidence is needed for some variables, such as health facilities, built density, and aesthetics. A universal and comprehensive understanding of the relationship between environment and health is crucial for developing policies and interventions that promote well-being and meet social needs.

# 1 INTRODUCTION

## 1.1 Background

There are many determinants that influence public health. For example, it is discovered that the determinants of premature deaths are generally considered as unhealthy diet, smoking and low physical activity (Manuel et al., 2016). While simply focusing on individual level determinants of health is not enough, moreover some objective factors affecting health such as environmental issues are of significance as well.

A health-social-environment ecosystem is proposed to engage deeply within communities and to better understand social-environmental influences of health (Quek, 2022). To be more detailed, the socio-ecological model divides influence of health into 2 main parts, which are environment and community. In terms of deeply analysing the multi-faceted connections between built environment and human health, summarizing multiple environmental characteristics, and determining how they contribute to the health outcomes is necessary.

Walkability is one outcome caused by multiple environmental factors. Meanwhile, walkability is associated with a safe community, high quality of built environment and sufficient green and blue spaces in the cities. Furthermore, walkability can also benefit human health. On the one hand, it is a kind of healthy behaviour that can help to efficiently prevent and better control chronic diseases and improve mental health (Baobeid, Koç & Al-Ghamdi, 2021). On the other hand, it encourages individuals to engage in physical activity and socialization (Zhu et al., 2014).

By affecting diet habits, mental health and physical activities, these environmental factors may indirectly impact on human health as well. In fact, some research studies found that the prevalence of mental health problems was often associated with the proportion of green space in a certain area (Lee, H. J., & Lee, D. K., 2019), and green space also correlates to individuals' physiological health (Park et al., 2009). Besides, a recent systematic review and meta-analysis noted that a walkable and safe community which can access to overall destinations and services is able to bring positive effect to elder groups in physical activity (Barnett et al., 2017). Another systematic review indicated a broader range of environmental characteristics including but not limited in climates, level of pollution and traffic conditions, and it also has more specific classification on the certain environmental characteristics in relation to public health and liveability which is better for our reference (Annear et al., 2014).

## 1.2 Aim

As the corresponding characteristics of the built environment may vary with the income level and topography of the certain country or area, current systematic reviews and meta-analyses especially focus on specific regions which makes the conclusions less universal. Additionally, environmental variables have different effects on health for different age groups. Hence, the purpose of this study is not only to systematically review the evidence on the relationships between built environment characteristics with public health in different regions and for age groups, but also to find the potential research trends and gaps for further related studies.

Upon completion of the study, we hoped to gain comprehensive insights into the impact of various environmental characteristics on public health. These findings would serve as a valuable reference for urban planners, aiding them in their efforts to make cities healthier and reducing the incidence of diseases among the populace, ultimately

improving their quality of life. Additionally, our systematic review aimed to answer the pivotal question of what steps we could take in the future to make our cities more conducive to good health and well-being.

With a clear understanding of the importance of understanding the relationships between the environment and public health, we identified the key factors that influence disease rates and develop strategies to combat them. By incorporating this knowledge into future urban planning initiatives, it is hoped that we could create healthier living spaces that promote physical and mental well-being. We could also help cities become more sustainable, reducing the environmental impact of urbanization and protecting the health of future generations.

Through our study, we aimed to provide a comprehensive and actionable roadmap for building healthier cities that prioritize the health and well-being of their citizens. We believe that by working together and taking a holistic approach to urban planning, we could create vibrant, livable communities that foster good health and a high quality of life for all.

### 1.3 Implications

This project aimed to study how environmental characteristics impact public health and how to provide a better environment to improve public health. There is increasing recognition that the challenges to public health and environmental characteristics are interconnected (Graham & White., 2016). Based on the research aim of this project, the relationships between them would be addressed together and understood more clearly.

There is a plethora of environmental factors that can significantly impact human health. MOHT's Health Precinct Framework, as outlined by Quek in 2022, divides these factors into two categories: community and environment.

Community factors encompass elements such as community safety, education, access to health and social services, population and built density, and community infrastructure. These elements play a crucial role in shaping the physical, social, and economic conditions of a community and can have a direct impact on public health outcomes. On the other hand, environmental factors refer to elements such as air and noise pollution control, land use diversity, street connectivity, access to public transportation, entertainment facilities, green and blue spaces, and access to healthy food. These environmental factors are also significant determinants of health outcomes, as they shape the physical environment in which individuals live and work.

We selected the mentioned environmental characteristics to investigate their impact on public health and propose solutions to enhance the quality of life and ecosystem services. Our project served as a modest contribution to the global effort to link environmental characteristics, social factors, and public health, paving the way for the development of more comprehensive policies aimed at improving public health outcomes. Through our research, we aimed to shed light on the complex relationships between environmental factors, social determinants of health, and public health outcomes. By examining the impact of these factors on health, we could identify areas for improvement and develop targeted interventions to address specific health concerns. This knowledge could also help us develop policies and guidelines that promote healthy living and a sustainable environment.

Ultimately, our goal was to promote a holistic approach to urban planning and development that prioritizes the health and well-being of individuals and communities. By recognizing the interconnectedness of environmental, social, and

health factors, we could create more livable, sustainable, and healthy communities that support the well-being of all. We hope that our research will contribute to this important endeavor and inspire further action towards creating a healthier future for all.

## 2 METHODS

### 2.1 Overview

We adopted a systematic literature review method which included data collection, data extraction and synthesis, data analysis and Meta-Analysis. For scopes, we mainly analysed the research method, experiment or other social science research processes and result parts of the journals collected with the protocol described as follows in section 2.4 during the title and abstract screening and full text review processes. And this systematic review will only consider publications like journal articles on environmental characteristics for public health.

### 2.2 Search strategy

We reviewed the databases PubMed, Scopus, and Web of Science Core Collection from Jan. 2013 to Jan. 2023. We used keywords of "mental health", "physical health", "self-rated health" and "social health" in combination with keywords of "Green Space", "Fast-Food Density", "Health Facilities Number", "Population Density, "Built Density", "Land Use Diversity", "Streets Connectivity", "Access to Public Transport", "Access to Social Facilities", "Access to Recreational Facilities/Entertainment Attractions)", "Aesthetics" and "Safety". Then we collected all the search results about public health. Duplicate articles were excluded.

In the selection of publications, they were included if they:

- Included a formal social science research.
- Studied a population of people or included a specific sample.
- Included one or several variables about environment stated above that potentially impact people's living quality and diseases complication rates.
- Were written in English.

Except for studies conducted in the general population, we would also like to include the those that were conducted in different age groups and mark them in the paper to illustrate the differences between distinct demographic groups.

In the selection of publications, they were excluded if they:

- Were conducted in specific subsamples (not age groups), such as patients and people with underlying medical conditions.
- Focused on environment variables that are discussed in less than 3 publications and did not have specific conclusions.
- Focused on general environment or general health instead of one or several specific environment variables public health outcomes.

A total of 35,048 papers were selected from the three databases, PubMed, Scopus, and Web of Science Core Collection, by three reviewers respectively. During title and abstract screening, three reviewers worked independently to screen if the title and abstract aligned with the selection of publications criteria which mentioned before. Furthermore, two reviewers cross-checked each other's work while when conflicts arise, another reviewer of the team would be involved to double check and voted for the final decisions. All papers were managed in Covidence systematic review management software (Covidence.org).

After the screening process finished, 4,088 papers were removed due to duplications. 28547 papers were excluded based on the criteria of publications selections. 2413 papers were included with the following items: source, title, publication year, environmental variables, corresponding public health, methodology, sample size, region, and result. After carefully full text review, only 116 papers were included. Furthermore, papers were screened and selected by manually search. Hence, there were totally 55 eligible papers for inclusion and for further data extraction and analysis.

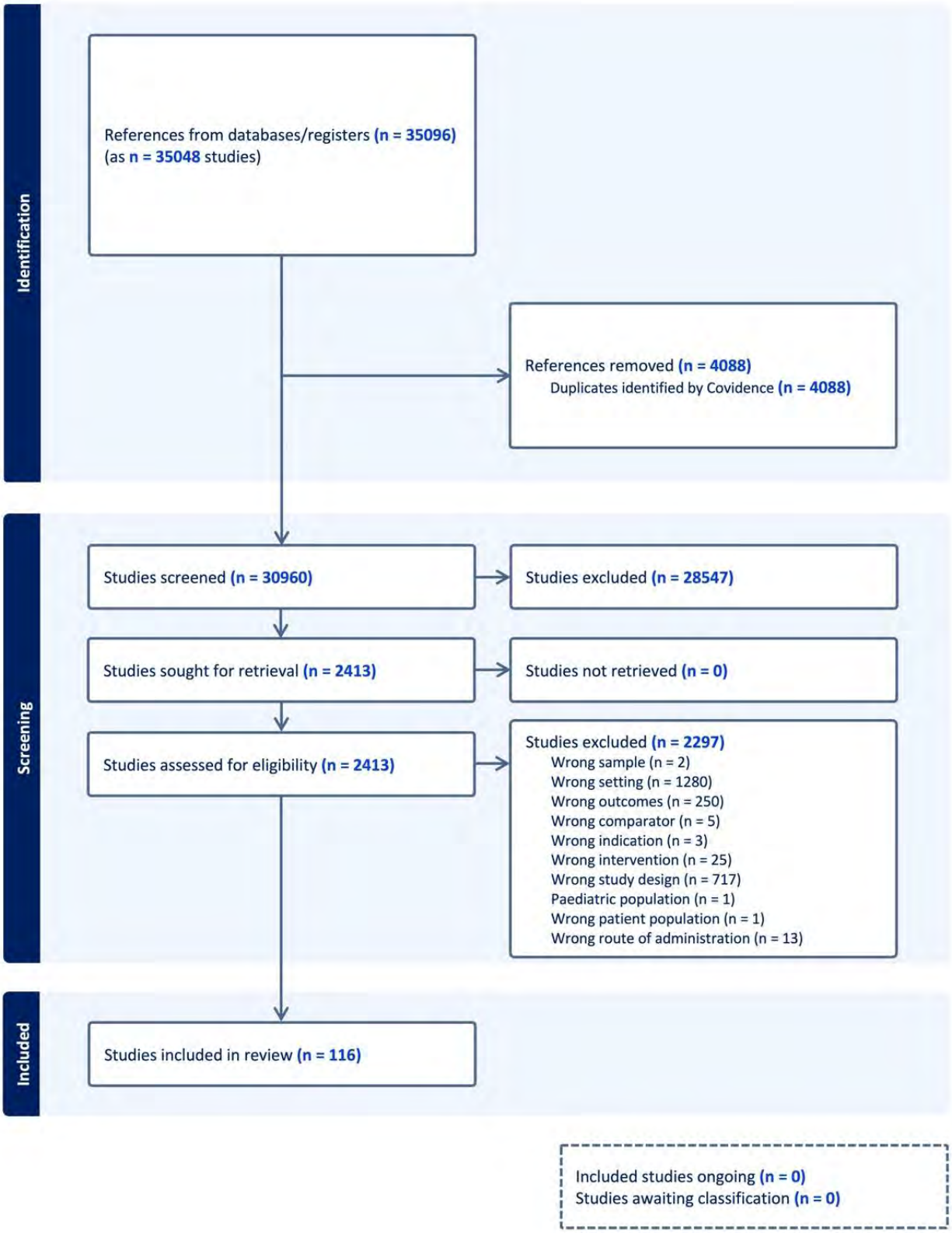


**Figure 1. Flow of study selection process**

## 2.3 Data extraction and synthesis

We extracted study information from reviewed articles which included title, author, publication year, environment factors, detailed health issues, study design, data collection method, region, sample size, basic sample characteristics (such as age and gender) and results. All the data we extracted were organized in a Microsoft Excel sheet. One of us led data extraction and synthesis from these articles, and the others would review data to ensure the accuracy and made the table.

### *2.3.1 Environment Variables*

When selecting environment variables, we referred to the definition of CDC (Centers for Disease Control and Prevention): “The built environment includes all of the physical parts of where we live and work (e.g., homes, buildings, streets, open spaces, and infrastructure). The built environment influences a person’s level of physical activity.” (CDC, 2021), We found environment variables which are studied in the 55 articles we chose, and finally selected eleven factors. They are areas of green space, density of fast-food restaurants, number of health facilities, population density, built density, land use diversity, streets connectivity, access to public transport, access to recreational facilities/entertainment attractions, aesthetics and neighbourhood safety, which are described as below:

- Green Space

Green space is defined as “an area of grass, trees, or other vegetation set apart for recreational or aesthetic purposes in an otherwise urban environment.” Also, green space in this project includes the water space (blue spaces) (Google Dictionary, 2023).

- Fast-Food Density

Fast food density is defined as the number of fast food ("easily prepared processed food served as a quick meal or to be taken away" (Google Dictionary, 2023).) restaurants in a certain area.

- Health Facilities Number

Describes the number of health facilities (A health facility is where healthcare is provided including small clinics, hospitals and so on. As "Health Facility", (2022) stated that "the number and quality of health facilities in a region is one common measure of that area's prosperity and quality of life".) in a certain area.

- Population Density

The population density describes how many people live in a given area.

- Built Density

The built density is the Rational Floor Area Ratio in a certain area. "Floor area ratio (FAR) is the ratio of a building's total floor area to the size of the piece of land upon which it is built." ("Floor area ratio", 2023).

- Land Use Diversity

“Land use” is used to describe how a land is used by people, including agricultural, residential, recreational uses, etc. (Land Use | US EPA, 2022). Land use diversity describes the number of different land use in a certain area.

- Streets Connectivity

Street connectivity is an indicator showing how well streets are connected, and "is typically measured as the density of intersections in a given area" (Street Connectivity - Australian Urban Observatory, 2022).

- Access to Public Transport

The variable describes the walkability and accessibility of public transportation including subway stations, bus services and railway stations.

- Access to Social Facilities

The variable describes the walkability and accessibility of social facilities that are defined as facilities built for people to social with each other such as public communication room. (Social Facility, n.d.).

- Access to Recreational Facilities/Entertainment Attractions

Recreational Facilities/Entertainment Attractions are kinds of facilities that are public places where "members of a community gather for recreational activities, including playground, gym, court, etc." (Villanueva et al., n.d.).

- Aesthetics

Built environmental aesthetics is subjective and may differ in groups of people. However, there are still some more general perceptions about the aesthetics of the built environment. For example, neat, pleasantly landscaped, well-designed spaces are more likely to be perceived as "beautiful" and "aesthetic". Also, a more realistic way to evaluate aesthetics is to use the "Neighborhood Environment Walkability Scale Questionnaire".

- Safety

Safety is defined as "the condition of being safe from undergoing or causing hurt, injury, or loss" (Merriam-Webster, n.d.). It can also be referred as the mental status of being protected and assuring. And it can be associated with the crime rates in a certain area.

### *2.3.2 Public Health*

In WHO’s (World Health Organization) definition, health is “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, 1946), so when we discussed public health, we referred to their definition and decided to take physical, psychological, and social well-being health into account. Besides these kinds of health, people would have an overall perception of their health in their daily life, so we also considered people’s self-rated health. Therefore, the public health in our study contains four parts: physical health, mental health, self-rated health and social health. Within these four types of health are many more detailed health issues. We identified specific health issues in the articles and explore the impact of environmental variables on them.

# 3 RESULTS

## 3.1 Study Characteristics

Fifty-five articles were included in the review (Table 1 in Appendix). Articles were published between 2013 and 2023. Among these articles, 45.5% of them (n=25) were published between 2013 and 2019, 54.5% of them (n=30) were published between 2020 and 2023, with 6 articles in 2020, 9 articles in 2021, 12 articles in 2022 and 3 articles in 2023, which means the interest of researchers has a rapid growth in this research area in recent years. Regarding the study region, 47.3% of the studies (n = 26) were taken in Asia, of which sixteen were in China, three were in Singapore, and others were in Hong Kong, Japan, Malaysia and Korea, 25.5% (n = 14) studies were conducted in North America and eleven of them were in the United States, 14.5% of studies (n = 8) were conducted in European, 5.4% of studies (n = 3) were conducted in Australia and 5.5% of studies (n = 3) were conducted in South America and 1.8 % of studies (n = 1) was in Africa. Some studies were conducted in multiple places, for example, Loo et al. (2017) conducted their study in Hong Kong, Singapore and Tokyo, and Stevenson et al. (2016) studied people in the United States, Australia, India, China and Denmark. All the articles took both male and female into consideration when they chose sample. The smallest sample size was 28, and the biggest sample size was 591,303. Twelve (25%) studies designed a sample size between 200 and 1000, sixteen (33.3%) studies designed a sample size between 1000 and 10000, and twenty-one (43.75%) studies had a sample size over 10000. Most studies used cross-sectional data. In terms of the objective measurements of to collect the environment information, GIS was used most widely (35.4%). The method used most frequently in studies were questionnaire survey (33.3%) and interview (8.3%). All these studies discussed how the environment influences public health, but they focused on different environment variables. Twenty-nine studies focused on the area of green space or blue space, twelve studies focused on the density of fast-food restaurants, two studies focused on health facilities density, six studies focused on population density, three studies focused on built density, five studies focused on land use diversity, ten studies focused on streets connectivity access to public transport, eight studies focused in access to recreational facilities or entertainment attractions, four studies focused on aesthetics, and five studies focused on safety.

## 3.2 Environmental Variables and Health

### a. The Area of Green Space and Health

| Health Type | Detailed Health Issues | Positively-Associated | Negatively-Associated | Non-significant |
|---|---|---|---|---|
| **Mental health** | | Zhou et al., 2022<br>Zhang et al., 2021<br>Nieuwenhuijsen, 2022<br>Nieuwenhuijsen, 2016<br>Wang et al., 2022<br>Loo et al., 2017<br>Zhang et al., 2021<br>Yue et al., 2022<br>Grazuleviciene et al., 2021 | | |
| **Physical health** | | Loo et al., 2017<br>Takemoto et al., 2015<br>Nieuwenhuijsen, 2016<br>Feng & Astell-Burt, 2017<br>Chan & Liu, 2018 (indirectly)<br>Grazuleviciene et al., 2021 | | |
| | Cardiovascular disease | | Seo et al., 2019<br>Yu et al., 2023 (for the moderate-risk group) | |
| | Chronic disease | | Dennis et al., 2020<br>Chien et al, 2022 | |
| | Diabetes | | | Chien et al., 2022 |
| | Obesity | | Zhong et al., 2022<br>Chen et al., 2020<br>Zhou et al., 2017<br>Blas-Miranda et al., 2022<br>Mylona et al. 2020 | Chien et al., 2022 |
| **Self-rated health** | | Carter, M., & Horwitz, P., 2014<br>Yang et al., 2022 | Lin, C. & Wu, L., 2021(blue space) | Lin, C. & Wu, L., 2021 (green space)<br>Wan et al., 2022 |
| **Social health** | | | | |

**Table 3.2.1. Summary of the area of green space and health studies**

There are 29 studies showing the area of green space is significantly associated with mental health (general mental health and stress level), physical health (general physical health, cardiovascular disease, chronic disease, diabetes and obesity) and self-rated health. While there is no evidence for the association between greenery and social health.

First, for **physical health**, 58.62% of the (n = 17) studies discussed the relationships between the area of green space and physical health, and all of them proved they are positively associated. Two studies among them found that green space would negatively associate with chronic diseases. Another two studies found the area of space was negatively associated with cardiovascular disease. Six studies discussed the relationships between green space and obesity, and 83.3% (n = 5) of them suggested they were negatively associated, while one held the view that the relationship between them was non-significant. Chien et al. (2022) studied the relationship between green space and diabetes, and they found their relationship non-significant, that might be because the median level of their NDVI (Normalized Difference Vegetation Index), was much lower than other study, and the special built-up environment with low vegetation and high population density of their study area.

Second, for **mental health**, 31.03% (n = 9) of the studies investigated how the area of green space influenced people's mental health, and they all found that it influenced people's mental health positively.

Third, for **self-rated health**, 10.34% (n = 3) of the studies discussed the relationship between green space and self-rated health, and the conclusions were controversial. Some (n = 2) of them think their relationship is positively associated, while fewer (n = 1) of them think it is negative. The rest (n = 1) holds that the relationship between them is non-significant. It is worth noting that green space and blue space may affect self-rated health in different ways. Lin & Wu (2021) believe that blue space is negatively associated with the elder's self-rated health, however, green space has little impact on it, because "the elder are often less inclined to travel longer distances to use green spaces and blue space due to physical limitations and long-term illnesses, and thus cannot actively used them to promote their health". What is worse, "the poor or polluted water quality in rivers or coastlines might negatively affect the elderly living close to rivers or coastal areas".

### b. The Density of Fast-Food Restaurants and Health

| Health Type | Detailed Health Issues | Positively-Associated | Negatively-Associated | Non-significant |
|---|---|---|---|---|
| **Mental health** | | | | |
| **Physical health** | Blood pressure | | | Mackenbach et al., 2019 |
| | Insulin resistance | Hsieh et al., 2014 | | |
| | Obesity | Zhou et al., 2017<br>Polsky et al., 2016<br>Hollands et al., 2014<br>Cheong et al. 2019<br>Burgoine et al., 2018<br>Mylona et al. 2020<br>Rossi et al., 2023<br>Hall et al., 2021 | | Mazidi et al., 2017<br>Harbers et al., 2021 |
| **Self-rated health** | | | | |
| **Social health** | | | | |

**Table 3.2.2. Summary of the density of fast-food restaurants and health studies**

There are 12 studies supporting the association between the density of fast-food restaurants (DFFR) and physical health (blood pressure, insulin resistance and obesity). However, there is no evidence for the association between DFFR and mental health, self-rated health or social health.

For **physical health**, all (n = 12) of the studies about DFFR are about physical health. First, among them, 83.3% (n = 10) of these studies revealed the correlation between DFFR and obesity. Most of these obesity related studies reflected a positive relation between DFFR and obesity. Only 22.2% (n = 2) of them reported a statistically non-significant association (Mazidi et al., 2017 and Harbers et al., 2021). However, the two articles neither use a specific sample, nor were they studied in the same area. So, the unexpected results are worth noting. Second, one (n = 1) of the studies found a relation between DFFR and insulin resistance, which could be a cause of diabetes in the future. It showed a result of positive correlation between the variables. Third, one (n = 1) of the studies researched on the correlation between health and blood pressure, however, the study reported a non-significant association.

### c. The Number of Health Facilities and Health

| Health Type | Detailed Health Issues | Positively-Associated | Negatively-Associated | Non-significant |
|---|---|---|---|---|
| **Mental health** | | | Wan et al., 2022 | |
| **Physical health** | Blood pressure | | Alcalde-Rabanal et al., 2018 | |
| | Diabetes | | Alcalde-Rabanal et al., 2018 | |
| | Obesity | | Alcalde-Rabanal et al., 2018 | |
| **Self-rated health** | | Wan et al., 2022 | | |
| **Social health** | | | | |

**Table 3.2.3. Summary of the number of health facilities and health studies**

There are 2 studies reviewed about the influence of the number of health facilities (NHF) on mental health (general mental health), physical health (diabetes, blood pressure and obesity) and self-rated health. However, there is no evidence for the association of NFH with social health.

First, one of the studies is about **mental health**. And it reported a negative effect of NHF on mental health. "Interestingly, our research confirmed that the perceived accessibility of community hospitals is negatively correlated with SRMH (mental health). One possible explanation might be that most residents feel that community health services have more negative health impacts (such as infectious illnesses and crowding) and that the higher the accessibility, the larger the negative health effects. However, the number and accessibility of general hospitals are much lower than those of community hospitals, and the adverse psychological effects brought by general hospitals are minimal." (Wan et al., 2022). We can see that the impact of NFH is not what we perceived before.

Second, one of the studies is about **physical health**. It showed that diabetes, blood pressure and obesity are negatively associated with the NHF (which means that health facilities would reduce the rates of diabetes, high blood pressure and obesity). It may be because people can deal with their health issues earlier if they are closer to health facilities.

Third, one of the studies discussed the impacts on **self-rated health**. It reported that "the higher the perceived accessibility of general hospitals, the higher the SRPH (self-rated physical health) level" (Wan et al., 2022). It corresponded with our perception that NFH would increase public self-rated health. However, it also stated that "the frequency of use of general hospitals was negatively correlated with SRPH." (Wan et al., 2022). It may be because "residents with poorer physical health status have a more significant demand for hospitals and are more likely to use them more frequently." (Wan et al., 2022). So, we could see that the impacts of NFH and the frequency of use of health facilities are different.

### d. Population Density and Health

| Health Type | Detailed Health Issues | Positively-Associated | Negatively-Associated | Non-significant |
|---|---|---|---|---|
| **Mental health** | | | Tao et al., 2020<br>Mueller et al., 2021 | |
| **Physical health** | Chronic disease | Stevenson et al., 2016 | | |
| | Diabetes | | Van Cauwenberg et al., 2019 | |
| | Infectious disease | Md Iderus et al., 2022 | | |
| | Respiratory disease | Stevenson et al., 2016 | | |
| | The mortality of chronic obstructive pulmonary disease | Wang et al., 2019 | | |
| **Self-rated health** | | | | |
| **Social health** | | | Mueller et al., 2021 | |

**Table 3.2.4. Summary of the population density and health studies**

There are 6 studies reviewed about the influence of the population density on mental health (general mental health), physical health (chronic disease, diabetes, infectious disease, respiratory disease and "the mortality of chronic obstructive pulmonary disease" mentioned in Wang et al., 2019) and social health, while there was no evidence for the association of population density with self-rated health.

First, some (n = 2) of the papers studied an association between population density and **mental health**. They drew the expected conclusion - that population density was negatively associated with mental health.

Second, more (n = 4) of the studies discussed the association between population density and **physical health**. Among them, one of the physical-health related papers is about chronic disease and respiratory disease, one is about diabetes, one is about infectious disease (in the paper, respiratory infectious diseases such as COVID-19) and the rest one is about "the mortality of chronic obstructive pulmonary disease". The conclusions showed that high population density would increase the rate of the respiratory diseases, infectious diseases, chronic diseases and the mortality of chronic obstructive pulmonary disease while it would decrease diabetes rates (Van Cauwenberg et al., 2019). This might be because the sample of the study were adults over 45 years old. Although different age groups might get different results and the results were not representative for all age groups, it was still worth noting as it may reveal the correlation between population density and the prevalence of diabetes in middle age or elder groups.

Third, for **social health**, Mueller et al. (2021) not only discussed mental health, but also included social health in the paper. Mueller et al. stated that high population density would negatively impact social health.

### e. Built Density and Health

| Health Type | Detailed Health Issues | Positively-Associated | Negatively-Associated | Non-significant |
|---|---|---|---|---|
| **Mental health** | | Melis et al., 2015 | | |
| **Physical health** | | | Chan, I. Y., & Liu, A. M., 2018 | |
| | BMI | Troy et al., 2018 | | |
| **Self-rated health** | | | | |
| **Social health** | | | | |

**Table 3.2.5. Summary of the built density and health studies**

There are 3 studies reviewing the influence of built density on mental health (general mental health) and physical health (general physical health and BMI, which can be an indicator of obesity). While there is no evidence for the association of population density with self-rated and social health.

First, one of them is about **mental health**. It found a positive relationship between built density and mental health, which did not correspond to our perception. Melis et al., (2015) found that urban density improves mental health only after age 50 for both man and women. More social activities resulted from higher urban density could be regarded as the reasons for the positive influence of built density on mental health.

Second, two of the studies are about **physical health**. Among them, one of them is about physical health and another one of them is about obesity. As expected, it was found that high built density negatively impacted physical health and increased obesity rates.

Interestingly, other studies have found a relationship between social networks among neighbors (maybe a result from built density) and health. In Zhou et al., (2017), "one-half of interviewees mentioned that social networks among their neighbors were a motivator to initiate, regulate, and maintain physical activities". This can be a moderator in the relationship between built density and mental or physical health.

## f. Land Use Diversity and Health

| Health Type | Detailed Health Issues | Positively-Associated | Negatively-Associated | Non-significant |
|---|---|---|---|---|
| **Mental health** | | Nieuwenhuijsen, 2016<br>Mueller et al., 2021 | | |
| **Physical health** | | Zhong et al., 2022<br>Nieuwenhuijsen, 2016<br>Mueller et al., 2021 | | |
| | Chronic disease | | Stevenson et al., 2016 | |
| | Obesity | | Zhou et al., 2017 | |
| **Self-rated health** | | | | |
| **Social health** | | | | |

**Table 3.2.6. Summary of the land use diversity and health studies**

There were 5 studies reviewed about the influence of land use diversity on mental health (general mental health), physical health (general physical health, chronic disease and obesity). However, there is no evidence for the association of population density with self-rated health or social health.

First, some (n = 2) of the studies discussed the relationship between land use diversity and **mental health**. They both found that higher land use diversity will increase the public mental health.

Second, more (n = 4) of the studies researched the correlation between land use diversity and **physical health**. And as expected, they all concluded that they are positively correlated. In addition, Stevenson et al., 2016 described that higher land use diversity will reduce chronic diseases and Zhou et al., 2017 introduced that land use would decrease obesity rates.

In conclusion, as concluded in all related studies, land use diversity is an environment variable that contributed to public health.

## g. Streets Connectivity and Health

| Health Type | Detailed Health Issues | Positively-Associated | Negatively-Associated | Non-significant |
|---|---|---|---|---|
| **Mental health** | | Bhuyan & Yuen, 2021<br>Meliset al., 2015<br>Yue et al., 2022<br>Mueller et al., 2021 | | |
| | | | Tao et al., 2020 | |
| **Physical health** | | Wu et al., 2022<br>Takemoto et al., 2015<br>Mueller et al., 2021 | | |
| | Chronic disease | Yue et al., 2022 | | |
| | Hypertension | Grazuleviciene et al., 2021 | | |
| | Obesity | | Leonardi et al., 2017 | |
| **Self-rated health** | | | | |
| **Social health** | | | | |

**Table 3.2.7. Summary of the streets connectivity and health studies**

There were 9 studies that examined the relationship between street connectivity (e.g., street pattern, access to sidewalks, pathway and intersections, road planning) and mental health (general mental health), physical health (general physical health, chronic disease, hypertension and obesity). However, there was no evidence for the association of street connectivity with self-rated health or social health.

First, some (n = 5) of the studies show the relation between street connectivity and **mental health**. The results of

these studies consistently show that street connectivity is significantly associated with better mental health outcomes. However, there was also some disagreement among the studies, as Tao et al. (2020) suggested that road connectivity may have a negative impact on people's mental health under certain circumstances. Specifically, increased air and noise pollution resulting from higher road connectivity can lead to stress and anxiety, which can negatively affect mental health.

Second, more (n = 6) of the studies found that street connectivity can improve **physical health**. For instance, higher street connectivity was associated with lower chronic disease risk (n = 1 of the physical-health related studies), lower obesity rates (n = 1), lower hypertension risk (n = 1). Additionally, street connectivity has been shown to improve general physical health (n = 3).

### h. Access To Public Transport and Health

| Health Type | Detailed Health Issues | Positively-Associated | Negatively-Associated | Non-significant |
|---|---|---|---|---|
| **Mental health** | | Crotti et al., 2021 (for eldly) | | |
| | | | Zhang et al., 2021 | |
| **Physical health** | | | Zhang et al., 2021 | |
| | | | | Mueller et al., 2021 |
| | Chronic disease | Yue et al., 2022 | | |
| | Obesity | | Oswald Beiler et al., 2018<br>Fuller et al., 2013<br>Song et al., 2020 | |
| **Self-rated health** | | Crotti et al., 2021 (for eldly) | | |
| **Social health** | | | | Bhuyan & Yuen, 2021 |

**Table 3.2.8. Summary of the access to public transport and health studies**

There were 8 studies that discussed the relation between the access to public transport and mental health (general mental health), physical health (general physical health, chronic disease and obesity), self-rated health and social health.

First, two (n = 2) of the studies are about **mental health**. Zhang et al. (2021) revealed that mental health was negatively related to access to public transport. However, Crotti et al. (2021) found that mental health was positively associated with the use of public transport, but only in the elderly population.

Second, more (n = 6) of the studies studied in-depth the influence of access to public health and **physical health**. Additionally, Zhang et al. (2021) revealed that physical health was negatively related to access to public transport, while Mueller et al. (2021) took a different perspective, stating that there was no direct and necessary link between physical health and the use of public transport. However, chronic disease was positively associated with access to

public transport as stated by Yue et al., (2022). Interestingly, most studies (n = 3) supported that obesity rates were found to be negatively associated with access to public transport, which means that the higher accessibility of public transportation would decrease obesity rates.

Third, one (n = 1) of the studies is about **self-rated health**. Crotti et al. (2021) found that self-rated health was positively associated with the use of public transport, but only in the elderly population.

Last, one (n = 1) study is about **social health**. Mueller et al. (2021) highlighted that there is no necessary connection between social health and public transport use.

In conclusion, these findings suggested that the relationship between access to public transport and health outcomes could be complex and multi-faceted. While access to public transport could have positive health benefits, such as improved social connectivity and reduced risk of chronic disease, it can also have negative effects on mental and physical health. And its impacts differed in different age groups.

### i. Access to Recreational Facilities/Entertainment Attractions and Health

| Health Type | Detailed Health Issues | Positively-Associated | Negatively-Associated | Non-significant |
|---|---|---|---|---|
| **Mental health** | | Deng & Paul, 2018<br>Yue et al., 2022<br>Tao et al., 2020<br>Gupta et al., 2023<br>Zhang et al., 2021 | | |
| **Physical health** | | Zhang et al., 2021<br>Deng & Paul, 2018<br>Song et al., 2020 | | |
| | Chronic disease | Dennis et al., 2020 (for low income eldly)<br>Song et al., 2020 | | Dennis et al., 2020 (for young) |
| | Functional health | Deng & Paul, 2018 | | |
| | Obesity | Song et al., 2020<br>Oswald Beiler et al., 2018 | | |
| **Self-rated health** | | | | |
| **Social health** | | | | |

**Table 3.2.9. Summary of the access to recreational facilities/entertainment attractions and health studies**

There were 8 studies discussed the relationships between the access to recreational facilities and entertainment attractions, such as urban park density, being associated with mental health (general mental health), physical health

(general physical health, chronic disease, functional health and obesity). However, there was no evidence for the association of street connectivity with self-rated health or social health.

First, five (n = 5) of the studies were about **mental health**. They all revealed a positive impact of recreational facilities and entertainment attractions as we perceived.

Second, five (n = 5) of the studies also involved the topic of **physical health**. Among them, the majority of health outcomes was positively associated with the accessibility of recreational facilities. However, a controversial finding was announced by Dennis et al. (2020), suggesting that the accessibility of recreation features was only positively associated with reducing chronic disease risk among low-income elderly individuals, as they had low physical mobility. For young generations, the study illustrated that this factor had little impact on chronic disease risk.

In conclusion, these findings suggested that the availability of recreational facilities and entertainment attractions could have significant health benefits, particularly for low-income elderly individuals. However, the impact of such amenities might vary depending on age and physical mobility. As such, it was essential to consider age-specific needs when designing and planning recreational facilities and entertainment attractions.

### j. Aesthetics and Health

| Health Type | Detailed Health Issues | Positively-Associated | Negatively-Associated | Non-significant |
|---|---|---|---|---|
| **Mental health** | | Zhang et al., 2022<br>Zhu et al., 2023 | | |
| **Physical health** | Obesity | | Malambo et al., 2017 | |
| **Self-rated health** | | | | |
| **Social health** | Regional brain volume | Fujiwara et al., 2022 | | |

**Table 3.2.10. Summary of the aesthetics and health studies**

There were 4 studies investigating the relationship between aesthetics, particularly park landscapes and the aesthetics of infrastructure or built environments, and mental health (general mental health), physical health (obesity) and social health (regional brain volume). However, there was no evidence for the association of street connectivity with self-rated health.

First, two (n = 2) of the reviewed studies indicated that aesthetics had a positive impact on the **mental health** of individuals.

Second, one (n = 1) of the studies is about **physical health** and it stated that aesthetics would decrease obesity rates. However, it is worth noting that none of the studies focused on chronic diseases, cancer, or infectious diseases, highlighting the need for further research to fully understand the relationships between aesthetics and various physical health outcomes.

Third, one (n = 1) of the studies is about **social health** and it perceived that aesthetics have a positive impact on the regional brain volume.

### k. Safety and Health

| Health Type | Detailed Health Issues | Positively-Associated | Negatively-Associated | Non-significant |
|---|---|---|---|---|
| **Mental health** | | Zhu et al., 2023<br>Bhuyan & Yuen, 2021 | | |
| | Stress level | Grazuleviciene et al., 2021 | | |
| **Physical health** | | Wu et al., 2022<br>Bhuyan & Yuen, 2021 | | |
| | Chronic disease | Hayward et al., 2015 | | |
| **Self-rated health** | | Hayward et al., 2015 | | |
| **Social health** | | Bhuyan & Yuen, 2021 | | |

**Table 3.2.11. Summary of the safety and health studies**

There were 5 studies that revealed that community safety is related to mental health (general mental health and stress level), physical health (general physical health and chronic disease), self-rated health and social health.

First, three (n = 3) of them discussed the relation of safety and **mental health**. Zhu et al., (2023) and Bhuyan & Yuen, (2021) stated that community safety would improve individuals' mental health. And those who live in safer neighbourhoods experience lower levels of stress (Hayward et al., 2015).

Second, three (n = 3) are about **physical health**. They concluded that community safety would reduce the risk of chronic disease compared to those residing in high-crime areas (Hayward et al., 2015).

Third, one (n = 1) is about self-rated health. It is also revealed that community safety is beneficial to **self-rated health**.

Last, one (n = 1) of them discussed the relation of safety and **social health**. To be more specific, individuals living in safer neighbourhoods had higher levels of social health, as they were more likely to engage in social activities with other community members (Bhuyan & Yuen, 2021),

Hence, these findings emphasised the importance of creating safe and secure communities for promoting positive health outcomes. By improving community safety, environments could be created that supported the well-being of individuals and promoted healthy living. Furthermore, our findings suggested that interventions that promote community safety could have a broad range of health benefits, including improvements in mental and physical health, social connections, and overall quality of life.

## 4 DISCUSSION

Our systematic review supported the relationship between environmental variables ("Green Space", "Fast-Food Density", "Health Facilities Number", "Population Density, "Built Density", "Land Use Diversity", "Streets

Connectivity", "Access to Public Transport", "Access to Social Facilities", "Access to Recreational Facilities/Entertainment Attractions)", "Aesthetics" and "Safety") and public health (obesity, blood pressure, mental health, chronic diseases, cardiovascular disease, diabetes, infectious disease, physical health, etc.).

We reviewed the studies around the world and there are the most studies that researched about the correlation of the area of green space and blue space and public health. Among them, the relationships between the area of green space and mental health and physical health are significant. Despite some studies focusing on different age groups (For example, Lin, C. & Wu, L., 2021 reported a negative correlation between blue spaces and self-related health and a non-significant relationship between greenness and self-related health.) reported non-significant relationship, most of the other public health factors are associated with greenness. From these studies, we can see the positive moderating effect of green space on public health.

Also, there are some environmental variables that got sufficient evidence for their relationship between some public health factors. The density of fast-food restaurants is proven by most related studies to be positively correlated with obesity. The land use diversity is also reported to be positively associated with physical health. Moreover, street connectivity is also positively associated with mental health and the access to public health will reduce the obesity rates, according to the reviewed studies.

However, for some environmental variables, there is a recognized need for further evidence to stress their relationship with public health, for example, less than five studies that studied the relationship between health facilities, built density, aesthetics and health, are reviewed. A more detailed relation between environmental variables and public health especially for these variables described above needs to be studied, which is a current research gap for potential further study.

Our study is new as previously few studies had systematically reviewed all related research about urban form and public health around the world and for different age groups from 2013-2023. So, the results are up to date and universal. As proposed in our results part, there are some environmental variables that might be related to some specific public health, while they are not studied in the context we found. For example, some studies suggested a relationship of population density and outdoor activities, while they did not delve into the moderating role of physical activity in the impact of population density on health. Also, the environmental variables do not influence public health separately, they probably work together when influencing public health. For example, land use diversity may work together with the area of green spaces and built density to influence the obesity rates of people. However, most studies that researched about the influence of multiple environmental variables did not do detailed data collection and research based on a certain sample instead they only do literature collection and logistic reasoning based on previous studies. So, for further study, it might be better to study the influence of multiple environmental variables in depth.

Also, there are also some limitations for public health factors. As the study time range is from 2013-2023 and many reviewed studies were from 2019. It might be influenced by COVID-19 to some degree. For example, when we reviewed the studies about population density and infectious diseases, the most studies found were about COVID-19, which would decrease the diversity of our systematic review.

However, there are still some limitations in our study. Although our study included a lot of studies in the three databases. However, within a limited time period, we did not study in-depth the scientific qualities of these studies, including sample selecting, validity and reliability.

Although, there are more environmental variables and public health factors not included in the systematic review, the conclusions drawn from the reviewed literatures are still valuable for identifying the relationship between environmental variables and public health and gain insights in the current studies trend.

## 5 CONCLUSION

The basic purpose of our systematic review was to identify the correlation between environmental variables and public health, while also assessing the current trends and gaps in research on this topic. To conclude, our systematic review summarized more than 50 papers and looked into 11 environmental variables with unbalanced samples, and 11 public health characteristics. In conclusion, our findings provide valuable evidence for scholars and researchers interested in examining how built environment characteristics impact public health.

What should be noticed in our systematic reviews is not all correlations between environmental variables and public health characteristics illustrate statistical significance and the results are different according to the specific subjects' demographics (e.g., adolescent, seniors over 70 and middle-aged people) and geographical features (e.g., China, U.S and Europe). Hence, it can help us better analyse different results under the joint effect of multiple environmental variables and we need to analyse the specific situation in a targeted manner.

Furthermore, in our review's findings, it illustrates that some countermeasures need to be taken when built environment has negative impact on public health outcomes which also provide us great insights of further study in how to tackle consequential problems caused by built environment factors. Meanwhile, because in many cases, environmental factors are not directly responsible for the outcome of public health. We systematically review some conclusions derived from specific papers that differ greatly from the results analysed from majority of papers, future research was supposed to pay more attention to exploring the causation of determining factors that at different hierarchy level.

## APPENDIX

### Table 1. Summary of study characteristics

| Author, (Year), Reference | Location | Sample Size | Age Range | Objective Measurements of Built Environment | Environment Variables | Public Health |
|---|---|---|---|---|---|---|
| Blas-Miranda et al., 2022 | Mexico | 12631 | 20-59 | GIS methods | The Area of Green Space | obesity |
| Carter, M., & Horwitz, P., 2014 | Australia | 440 questionaire survey, 25 face-to-face interview | N.A. | questionaire survey, face-to-face interview | The Area of Green Space | self-reported health |
| Chan, I. Y., & Liu, A. M., 2018 | Hong Kong | 200 | both students and adults | questionaire survey | built density, The Area of Green Space | eyes disease, nose and throat problems, lethargy or tiredness, dry, itching or irritated skin |
| Chen et al., 2020 | China | 1000 | 18-70 | questionaire survey | The Area of Green Space | obesity (BMI) |
| Chien et al., 2022 | China | 40375 | over 30 | GIS databases | The Area of Green Space | chronic kidney disease, obesity and diabetes |
| Dennis et al., 2020 | UK | >550,000 | over 20 years of age | green infrastructure (GI) approach | The area of green/blue space, Access To Recreational Facilities/Entertainment Attractions) | chronic disease |
| Feng & Astell-Burt, 2017 | Australia | 10090 | 0-13 | face-to-face interview | The Area of Green Space | sub-optimal general health |
| Grazuleviciene et al., 2021 | Lithuania | 1086 | 45–64-year-old | GIS metrics | The area of green/blue space, street connectivity, safty | stress level, hypertension |
| Loo et al., 2017 | Hong Kong, Singapore and Tokyo | 687 | over 65 | observational and questionnaire surveys | The area of green/blue space | mental health |
| Lin, C., & Wu, L., 2021 | China | 1773 | over 60 | data from CSS | The Area of Green Space and blue space | self-rated health (SRH) |
| Nieuwenhuijsen, 2022 | Spain | 3145 | 15-97 | GIS databases | The Area of Green Space | mental health |
| Seo et al., 2019 | Korea | 351409 | over 20 | Archival databases | The Area of Green Space | cardiovascular disease |
| Takemoto et al., 2015 | US | 279 | over 65 | GPS data | Street connectivity, the Area of green space | physical health |
| Wan et al., 2022 | China | 591303 | 18-85 years | GIS | the area of green/blue space, access to health facilities | self-rated health, mental health |
| Yang et al., 2020 | China | 15477 | over 18 | GIS methods | The Area of Green Space | Cardiometabolic Disorders, and cardiovascular disease |
| Yang et al., 2022 | China | 682 | 18-65 | questionaire survey | The area of green/blue space | self-rated health |
| Yue et al., 2022 | US | 72,578 | over 65 | GIS | The area of green/blue space, street connectivity, access to public transport | Mental health, stress level, chronic disease |
| Zhang et al., 2021 | Singapore | 1000 | N.A. | survey, GIS | The Area of Green Space | mental health |
| Zhang et al., 2021 | China | 1003 | 18-59 | GIS | The area of green space/blue space, access to public transport, access to recreational facilities/entertainment attractions | mental health |
| Zhou et al., 2017 | China | 189 | 35-49 | GIS | The area of green/blue space, the density of fast food restaurant, land use diversity | obesity rate |
| Zhou et al., 2022 | China | 7397 | over 45 | Archival databases | The Area of Green Space | mental health |
| Burgoine et al., 2018 | UK | 51361 | 38–72 | GIS | The Density of Fast-Food Restaurants | obesity |
| Cheong et al. 2019 | Peninsular Malaysia | 5544 | 5-18 | GIS | The Density of Fast-Food Restaurants | obesity |
| Hall et al., 2021 | China | 1388 | over 18 | GIS | The Density of Fast-Food Restaurants | obesity |
| Harbers et al., 2021 | the Netherlands | 8231 | 20–69 | Archival databases | The Density of Fast-Food Restaurants | obesity |
| Hollands et al.,2014 | Canada | 89733 | 18 to 65 | Archival databases | The Density of Fast-Food Restaurants | obesity |
| Hsieh et al., 2014 | US | 453 | 8-18 | Archival databases | The Density of Fast-Food Restaurants | insulin resistance |
| Mackenbach et al., 2019 | the Netherlands | 1543 | N.A. | GIS | The Density of Fast-Food Restaurants | blood pressure |
| Mazidi et al., 2017 | US | > 400,000 | over 20 | Archival databases | The Density of Fast-Food Restaurants | obesity |
| Mylona et al. 2020 | US | 20297 | over 18 | Archival databases | The Density of Fast-Food Restaurants | obesity |

| | | | | | | |
|---|---|---|---|---|---|---|
| Polsky et al., 2016 | Canada | 10199 | over 18 | Archival databases | The Density of Fast-Food Restaurants | weight status |
| Rossi et al., 2023 | Brazil | 2026 | 7 to 14 years | selfadministered survey | The Density of Fast-Food Restaurants | obesity rate |
| Alcalde-Rabanal et al., 2018 | Mexico | 10326 | over 18 | Survey | Health Facilities | Diabets, Blood Pressure and Obesity |
| Md Iderus et al., 2022 | Malaysia | Malaysian census | N.A. | census databases | Population density | Respiratory infectious diseases |
| Stevenson et al., 2016 | US/Australia/ India/China/ Denmark | 100 000 | over 20 | DALYs database | population density, land use diversity | infectious disease, chronic diesease |
| Van Cauwenberg et al., 2019 | Australia | 4876 | over 45 | census databases | Population density | diabetes |
| Wang et al., 2019 | China | 1511 | N.A. | GWR | Population density | the mortality of Chronic Obstructive Pulmonary Disease |
| Melis et al., 2015 | Italy | Men (272, 516) and women (274, 747) | 20-64 | data from TLS (Turin Longitudinal Study), statistical analysis | Built Density, Access To Public Transport | mental health |
| Troy et al., 2018 | US | a dataset of adult diabetics (n = 610);the complete driver's license records for Vermont (n = 401,367) | N.A. | cross-sectional analysis | Built Density | body mass index (BMI) |
| Zhu et al., 2023 | US | 1252 | 38.8+-12.5 | Neighborhood Environment and Walkability Survey | Land use diversity, safety, Aesthetics | mental health |
| Bhuyan & Yuen, 2021 | Singapore | 80 | 52 and above | FGD | street connectivity, access to public transport, safety | social health, mental health |
| Leonardi et al., 2017 | US | 17946 | over 20 | GIS databases | street connectivity | obesity |
| Song et al., 2020 | Singapore | 810 | over 55 | GIS | street connectivity, access to public transport, access to recreational facilities/entertinment attractions | chronic disease, obesity |
| Wu et al., 2022 | China | 1632 | over 18 | questionaire survey | Street connectivity | chronic disease |
| Crotti et al., 2021 | Italy | 15,097 | aged over 60 years | survey by ISTAT | Access to public transport | mental helath, self-rated health |
| Fuller et al., 2013 | US | 1440 | over 18 | Surveys and GIS | Access To Public Transport | obesity |
| Zhang et al., 2021 | China | 882 | over 60 | questionaire survey | Access To Public Transport Access To Recreational Facilities/Entertainment Attractions | self-evaluation of physical health, physical function, and physical pain |
| Deng & Paul, 2018 | China | 5949 | age 45 or older | CHARLS database | Access to recreational facilities/entertainment attractions | mental health, functional health |
| Gupta et al., 2023 | Canada | 24960 | over 35 | (Can-ALE) database | Access To Recreational Facilities/Entertainment Attractions | mental health |
| Tao et al., 2020 | China | 50 in-person interviews, 1256 survey | N.A. | in-person interviews and questionaire survey | Access To Recreational Facilities/Entertainment Attractions, Population density, Streets Connectivity | mental health |
| Yue et al., 2022 | China | 879 | over 60 | interview, statistical analysis | Access To Recreational Facilities/Entertainment Attractions | mental health |
| Fujiwara et al., 2022 | Japan | 476 | 65-84 | questionaire survey | Aesthetics | regional brain volume |
| Malambo et al., 2017 | South Africa | 671 | over 35 | Scale Questionnaire | Aesthetics | obesity |
| Zhang et al., 2022 | China | 293 | 21-92 | questionaire survey | Aesthetics | mental health |
| Hayward et al., 2015 | US | 28 | 21-71 | focus group survey | Safety | self-rated health, chronic disease |

**Table 2. Summary of Relationships between Environment Variables and Public Health**

| Environment Variables | Health Outcome | Detailed Health Issues | Statistical Associations | | |
|---|---|---|---|---|---|
| | | | Positively-Associated | Negatively-Associated | Non-significant |
| The Area of Green Space/ blue space | Mental health | | Zhou et al., 2022 | | |
| | | | Zhang et al., 2021 | | |
| | | | Nieuwenhuijsen, 2022 | | |
| | | | Nieuwenhuijsen, 2016 | | |
| | | | Wang et al., 2022 | | |
| | | | Loo et al., 2017 | | |
| | | | Zhang et al., 2021 | | |
| | | | Yue et al., 2022 | | |
| | | | Grazuleviciene et al., 2021 | | |
| | Physical health | | Loo et al., 2017 | | |
| | | | Takemoto et al., 2015 | | |
| | | | Nieuwenhuijsen, 2016 | | |
| | | | Feng & Astell-Burt, 2017 | | |
| | | | Chan & Liu, 2018 (indirectly) | | |
| | | | Grazuleviciene et al., 2021 | | |
| | | cardiovascular disease | | Seo et al., 2019 | |
| | | | | Yu et al., 2023 (for the moderate-risk group) | |
| | | chronic disease | | Dennis et al., 2020 | |
| | | | | Chien et al, 2022 | |
| | | diabetes | | | Chien et al., 2022 |
| | | obesity | | Zhong et al., 2022 | |
| | | | | Chen et al., 2020 | |
| | | | | Zhou et al., 2017 | |
| | | | | Blas-Miranda et al., 2022 | |
| | | | | Mylona et al. 2020 | |
| | | | | | Chien et al., 2022 |
| | Self-rated health | | Carter, M., & Horwitz, P., 2014 | | |
| | | | Yang et al., 2022 | | |
| | | | | Lin, C. & Wu, L., 2021(blue space) | |
| | | | | | Lin, C. & Wu, L., 2021 (green space) |
| | | | | | Wan et al., 2022 |
| The Density of Fast-Food Restaurants | Pysical health | blood pressure | | | Mackenbach et al., 2019 |
| | | insulin resistance | Hsieh et al., 2014 | | |
| | | obesity | Zhou et al., 2017 | | |
| | | | Polsky et al., 2016 | | |
| | | | Hollands et al., 2014 | | |
| | | | Cheong et al. 2019 | | |
| | | | Burgoine et al., 2018 | | |
| | | | Mylona et al. 2020 | | |
| | | | Rossi et al., 2023 | | |
| | | | Hall et al., 2021 | | |
| | | | | | Mazidi et al., 2017 |
| | | | | | Harbers et al., 2021 |
| Health Facilities density | Mental health | | | Wan et al., 2022 | |
| | Pysical health | blood pressure | | Alcalde-Rabanal et al., 2018 | |
| | | diabetes | | Alcalde-Rabanal et al., 2018 | |
| | | obesity | | Alcalde-Rabanal et al., 2018 | |
| | Self-rated health | | Wan et al., 2022 | | |
| Population Density | Mental health | | | Tao et al., 2020 | |
| | | | | Mueller et al., 2021 | |
| | Pysical health | chronic disease | Stevenson et al., 2016 | | |
| | | diabetes | | Van Cauwenberg et al., 2019 | |
| | | infectious disease | Md Iderus et al., 2022 | | |
| | | respiratory disease | Stevenson et al., 2016 | | |
| | | the mortality of Chronic Obstructive Pulmonary Disease | Wang et al., 2019 | | |
| | Social health | | | Mueller et al., 2021 | |
| Built Density | Mental health | | Melis et al., 2015 | | |
| | Physical health | | | Chan, I. Y., & Liu, A. M., 2018 | |
| | | BMI | Troy et al., 2018 | | |

| | | | | | |
|---|---|---|---|---|---|
| Land Use Diversity | Mental health | | Nieuwenhuijsen, 2016 | | |
| | | | Mueller et al., 2021 | | |
| | Physical health | | Zhong et al., 2022 | | |
| | | | Nieuwenhuijsen, 2016 | | |
| | | | Mueller et al., 2021 | | |
| | | chronic disease | | Stevenson et al., 2016 | |
| | | obesity | | Zhou et al., 2017 | |
| Streets Connectivity | Mental health | | Bhuyan & Yuen, 2021 | | |
| | | | Meliset al., 2015 | | |
| | | | Yue et al., 2022 | | |
| | | | Mueller et al., 2021 | | |
| | | | | Tao et al., 2020 | |
| | Physical health | | Wu et al., 2022 | | |
| | | | Takemoto et al., 2015 | | |
| | | | Mueller et al., 2021 | | |
| | | chronic disease | Yue et al., 2022 | | |
| | | hypertension | Grazuleviciene et al., 2021 | | |
| | | obesity | | Leonardi et al., 2017 | |
| Access To Public Transport | Mental health | | Crotti et al., 2021 (pos for eldly) | | |
| | | | | Zhang et al., 2021 | |
| | Physical health | | | Zhang et al., 2021 | |
| | | | | | Mueller et al., 2021 |
| | | chronic disease | Yue et al., 2022 | | |
| | | obesity | | Oswald Beiler et al., 2018 | |
| | | | | Fuller et al., 2013 | |
| | | | | Song et al., 2020 | |
| | Self-rated health | | Crotti et al., 2021 (pos for eldly) | | |
| | Social health | | | | Bhuyan & Yuen, 2021 |

| | | | | | |
|---|---|---|---|---|---|
| Access To Recreational Facilities/Entertainment Attractions | Mental health | | Deng & Paul, 2018 | | |
| | | | Yue et al., 2022 | | |
| | | | Tao et al., 2020 | | |
| | | | Gupta et al., 2023 | | |
| | | | Zhang et al., 2021 | | |
| | Physical health | | Zhang et al., 2021 | | |
| | | | Deng & Paul, 2018 | | |
| | | | Song et al., 2020 | | |
| | | chronic disease | Dennis et al., 2020 (for low income eldly) | | |
| | | | Song et al., 2020 | | |
| | | | | | Dennis et al., 2020 (for young) |
| | | functional health | Deng & Paul, 2018 | | |
| | | obesity | Song et al., 2020 | | |
| | | | Oswald Beiler et al., 2018 | | |
| Aesthetics | Mental health | | Zhu et al., 2023 | | |
| | | | Zhang et al., 2022 | | |
| | Physical health | obesity | | Malambo et al., 2017 | |
| | Social health | regional brain volume | Fujiwara et al., 2022 | | |
| Safety | Mental health | | Zhu et al., 2023 | | |
| | | | Bhuyan & Yuen, 2021 | | |
| | | stress level | Grazuleviciene et al., 2021 | | |
| | Physical health | | Bhuyan & Yuen, 2021 | | |
| | | | Wu et al., 2022 | | |
| | | chronic disease | Hayward et al., 2015 | | |
| | Self-rated health | | Hayward et al., 2015 | | |
| | Social health | | Bhuyan & Yuen, 2021 | | |

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