IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 12(1)/2025, 175-186

Effectiveness of Green Space in Improving Mental Health: A Review

Shastitharran Baskaran
Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia
sbaskaran@graduate.utm.my

Shazmin Shareena Ab. Azis, Nur Hannani Ab Rahman, Nursyuhaida Aziz
Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

ABSTRACT

Increasing urbanisation throughout the world has increased the number of mental health cases in citizens, especially in metropolitan areas. Various studies have conveyed the positive linkage between increased green space exposure in the daily life of urban citizens and mental health improvement. However, the current state of knowledge has limited information on percentage of effectiveness of green spaces in improving mental health. Apart from that, the contributions of green space attributes that enhance the improvement of mental health remains unclear. Thus, this study aims to discover the percentage of efficiency of green spaces in improving mental health through systematic review and meta-analysis. The formula for calculating confidence interval of odds ratio is used to calculate the standard error of each study and the random effect inverse-variance approach was used in the meta-analysis to identify the combined effect of the studies. Results from meta-analysis indicated that green spaces can provide an average of 17% [OR (95%CI): 0.83 (0.78–0.88)] improvement in the mental health of a person in terms of stress, depression, and anxiety. Apart from that, green space effectiveness in improving mental health varies with the influence of attributes such as bigger size, better accessibility, and higher tree density. The findings of this review provide evidence that green space exposure can improve the mental health of urban citizens. This study is significant to government bodies and developers as a guideline to implement more green spaces in urban areas that are filled with dense buildings. Overall, this review provides insights on social benefits of green space in improving mental health of citizens, indicating that green space that is accessible, big and has high density of greenness can be beneficial for urban citizen's mental health.

Article History

Received : *1 July 2024*
Received in revised form : *19 August 2024*
Accepted : *19 September 2024*
Published Online : *10 January 2025*

Keywords:

Urban Green Space, Greenness, Mental Health, Psychological Distress, Meta Analysis

Corresponding Author Contact:

sbaskaran@graduate.utm.my

DOI: 10.11113/ijbes.v12.n1.1369

© 2025 Penerbit UTM Press. All rights reserved

1. Introduction

The United Nations predicted that about 70% of the citizens around the world will live in cities by 2050, which indicates mass urbanisation. Due to the increasing urbanisation, the mental health conditions of citizens who are living in urban cities are harmed in various ways due to environmental stresses (Ma et al., 2019). The World Health Organization (WHO) has reported that between 35% to 50% of individuals living in wealthy nations struggle with significant mental health issues, and 76% to 85% of them do not receive any medical attention (Demyttenaere et al., 2004). Mental health is defined as a form of human health, which is the state of a person's equilibrium emotion that allows them to live their daily life comfortably with the people around them (Coronel & Rodriguez, 2022). A person with a stable mental health condition will have a good intellectual and soft skill which enables them to identify, perform and manage their emotions and feel bad for a person who is undergoing a rough life and does not become disappointed in themselves when they face difficult situations (Galderisi et al., 2015). There is also an important fact whereby that physical health, which relates to the body, and mental health, which relates to the mind of a person, is not two different things, but they are interrelated (Bhugra & Sartorius, 2013). According to the World Health Organizations (WHO), the common mental health symptoms include depression, anxiety, stress, schizophrenia, and bipolar disorder.

Moreover, urban-rural research that was conducted since 1985 found that issues relating to mental health are 38% higher in urban areas than in rural settings, with mood disorders at 39% higher, anxiety disorders at 21% higher, depression at 40% higher and a twofold increase in the risk of schizophrenia (Peen, 2010). According to Bojic (2018) and Lederbogen et al. (2013), one of the contributing factors that caused the increase in mental health issues in the community is due to a lack of exposure to greenery areas. The current mental health state of the citizens and its linkage with the green space exposure has become a trending interest within the built environment, government, and health sectors. The availability of open green space with an appropriate size according to the population size is essential to ensure that all the citizens in that radius of residence could enjoy the benefits of open space's benefits (Villanueva et al., 2015). Appropriate size of open spaces ensures the capability to occupy more citizens, more density of greenness exposure and higher availability of space for carrying out physical activities which contributes to the overall physical and mental health for the citizens.

Generally, green space is defined as a place covered with green plants and trees in an open metropolitan space (Taylor & Hochuli, 2012). A few examples of green spaces include forests, parks, gardens, urban greenery, green roof, and farms covered with various type of vegetations (Najihah & Abdullah, 2019; Zhao et al., 2010; Yuliani et al., 2020). Green spaces provide numerous benefits in terms of environment, such as urban water runoff control, pollution control and sound insulation, social benefits where it encourages social interaction between people in a calm environment, economic benefits such as reduction in electricity cost and health benefits such as stress reduction and improved general physical and mental health to the citizens (Azis & Zulkifli, 2021; Aram et al., 2019; Nath et al., 2018; Nero et al., 2017). The benefits provided are enjoyed by the citizens in two ways, which is the benefits received from directly using the green space and in direct use (Wilkerson et al., 2018).

Past researchers have emphasized that having greenery area exposures can lead to a decrease in anxiety, depression, and stress incidence rates (Grahn and Stigsdotter, 2003; Dannenberg et al., 2003) as well as improved overall mental health conditions (Croucher et al., 2008; Wood et al., 2017; Morita et al., 2007). The visits to green space in urban cities, such as parks and forests, is essential as exposure of a person to the greenery view could give them positive feelings, restorative effects and promote their well-being and few past researchers have reported there is a positive relationship between life cycle process of green space in an urban area and the citizen's mental health(Fuller et al., 2007; Carrus et al., 2015; Chiesura, 2004; Akpinar et al., 2016; Tsai et al., 2018; Nutsford et al., 2013). Green space provides a platform for the citizens to perform sports and recreation activities, promotes social interaction between citizens which leads to better health for the body and mind (James et al., 2009).

The literature evidence from various research shows a strong positive relationship between green space and the mental health of the community. The benefits of green space in the context of mental health promotion varies, and it could be an important key component that could reduce the overall mental health issues of the citizens.

Although there are numerous amounts of research that study the relationship between green space and mental health, the latest studies regarding the percentage of effectiveness of green space in improving different types of mental health is limited. The mental health state of the citizens all around the world is increasing together with urbanisation and ways to reduce the effects of these scenario towards the mental should be studied. In accordance with that, there is a need to understand and discover the benefits that nature exposure delivers towards improving mental health of citizens . Therefore, a systematic literature review and meta-analysis is carried out to discover the percentage of efficiency of green space towards mental health together with identifying the contributing attributes of green space in enhancing mental health improvement.

2. Materials & Methods

2.1 Data Collection - Selection of Studies

This review used systematic review and meta-analysis techniques based on the steps outlined in The Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) (Page et al., 2021). The systematic literature review is a process of data collection that identifies, evaluates, and analyses all the available studies that have been done in relevance to the research topic and particular area of research interest (Kitchenham,2007).

Past relevant studies were identified using various databases including Scopus, Web of Science and PubMed. Studies from various perspectives were derived, including environmental studies which focus on green space, health studies which focus on mental health and studies relating green spaces to mental health. At the initial stage of the search, no restriction was applied in terms of time as it is essential to obtain all the relevant studies regarding this topic to get a better understanding before filtering the studies according to this review's specific need. Various keywords were applied in the database search engines to obtain relevant studies which focus mainly on two categories, which are green space and mental health. From the received studies, the bibliographies of the studies were also focused on obtaining more relevant studies regarding this topic.

Several inclusion and exclusion criteria were used to ensure that the studies reviewed and chosen were relevant to the aim of this review. The inclusion criteria are, only studies which focus on mental health and not physical health, papers published in the English language, articles in journals and book chapters. As for exclusion criteria, articles that cannot be accessed and review articles are excluded. Relevant studies obtained are incorporated in the EndNote to identify duplicates, and all the duplicates are removed accordingly. As this review aims to discover the effectiveness of green space in improving mental health, the overall odds ratio from all the collected study results could indicate the percentage of effectiveness through meta-analysis. Several studies were excluded due to the absence of quantitative results that are essential to be included in the meta-analysis.

2.2 Data Analysis

The statical analysis was performed using MedCalc Software (version 22.021), following the guidelines outlined in the Cochrane Handbook (Higgins & Green, 2008). The population of each of the studies is recorded, and the weight of the effect is calculated to be used as an input in the meta-analysis.

The random effect inverse-variance approach was used to calculate the pooled effect of the studies. The inverse-variance method was used in the meta-analysis because we only had access to the odds ratio and the confidence intervals. Data availability does not include standard error of the odds ratio, but other information is provided where all these studies have 95% confidence intervals. In relation to that, the standard error was calculated using the odds ratio values together with its upper and lower limits. In general, the standard error of the logged odds ratio is calculated by using the formula stated in Eq. (1) where a and b are the event odds for the people who have exposure and c and d are event odds for people in the people who do not have exposure. The square root of the log odds ratio variance is the standard error (SE) of the study.

$$\text{Variance of Logged Odds Ratio} = (1/a + 1/b + 1/c + 1/d)$$
$$\text{Standard Error (SE)} = \text{sqrt}\,[1/a + 1/b + 1/c + 1/d] \quad (1)$$

Thus, the formula for the calculating of upper limit and lower limit of the 95% confidence intervals adopted from Tenny & Hoffman (2023) is used to determine the standard error of the respective studies. The 95% confidence intervals of the odds ratio are calculated by using the formula stated in Eq. (2), where the upper and lower limit of the confidence interval (95% CI) is stated in the result of the studies together with the odds ratio (OR). With the presence of these two data, the standard error of studies can be calculated.

$$\text{Upper 95\% CI} = e\ \hat{}\ [\ln(OR) + 1.96\ (SE)]$$
$$\text{Lower 95\% CI} = e\ \hat{}\ [\ln(OR) - 1.96\ (SE)] \quad (2)$$

From the formula in Eq. (2), we calculated the standard error of the respective studies by taking the natural log of both sides of the equations such as stated in Eq. (3)

$$\text{In}\ \{\text{Upper 95\% CI}\} = \ln(OR) + 1.96 \times SE\ \{\text{In}\ (OR)\}$$
$$\text{In}\ \{\text{Lower 95\% CI}\} = \ln(OR) - 1.96 \times SE\ \{\text{In}\ (OR)\} \quad (3)$$

From Eq. (3), we have the data regarding the upper limit and lower limit from the results of the studies together with the odds ratio. Then, to calculate the standard error, the formula is solved to identify the standard error of the logged odds ratio that derives Eq. (4) where the lower limit value of the studies is used.

$$SE\{\text{In}(OR)\} = \text{In}(\text{Lower 95\% CI})\} - \ln(OR)\} / \{-1.96\} \quad (4)$$

Once the standard error of the studies was calculated, the effect sizes of the studies, which is also known as the weight of the studies were calculated using MedCalc. The overall pooled effect of the studies was calculated using the odds ratio and the weight of the studies. Tests for heterogeneity were calculated using Cochran's Q statistics and I-squared statistics.

3. Results

The process of identifying and selecting studies for this review was carried out according to the PRISMA flow diagram that is shown in Figure 1. A total of 567 potential studies were identified by using the database search engines. As this review focuses on mental health promotion from the green space's exposure and benefits, studies that failed to adhere to the inclusion and exclusion criteria were excluded. After applying filters of the exclusion and inclusion criteria for the papers and reading the full text of the papers, a total of 12 studies were included in this systematic literature review, which portrays the needed information for the meta-analysis, such as the odds ratio together with the upper and lower limit of 95% confidence intervals.

The characteristics and information regarding the studies are tabulated in Table 1. The studies chosen were conducted in various countries, which include China (Zhou et al., 2022; Zhang et al., 2022), Australia (Astell-Burt et al., 2019; Feng et al., 2022), United States of America (Wang et al., 2019; Bezold et al., 2018; Fossa et al., 2024), Finland (Gonzales et al., 2022), Canada (Hystad et al., 2019), Mexico (Bakhtsiyarava et al., 2024), United Kingdom (Zhang et al., 2022) and Spain (Triguero et al., 2015). The studies used various methods and tools to identify the mental health and green space indicators to

understand the relationship between them. The tools used to assess mental health includes the Kessler 10 and 6 items scales (Astell-Burt et al., 2019; Wang et al., 2019; Feng et al., 2022), General Health Questionnaire (GHQ-12) (Pope et al., 2018; Triguero et al., 2015) and other studies used different type of scales such as Instrumental Activities of Daily Life Scale (IADL) and Centre for Epidemiological Studies-Depression Scale (CESD-10) (Zhou et al., 2022), McKnight Risk Factor Survey (MRFS) (Bezold et al., 2018), Health and Social Support Study (HeSSup) (Gonzales et al., 2022), 9 scales of Patient Health Questionnaire (Hystad et al., 2019), 7 scales of General Anxiety Disorder Scales (Hystad et al., 2019) and other remaining studies used medical records of the participants, custom questionnaires and surveys (Bakhtsiyarava et al., 2024; Fossa et al., 2024; Zhang et al., 2022).

As for the green space measurements, various attributes and indicators were considered in understanding the exposure to greenery. Most of the studies used the Normalized Difference Vegetation Index (NDVI) as an indicator to assess the density of greenness (Wang et al., 2019; Bezold et al., 2018; Gonzales et al., 2022; Hystad et al., 2019; Bakhtsiyarava et al., 2024; Fossa et al., 2024; Zhang et al., 2022; Triguero et al., 2015).

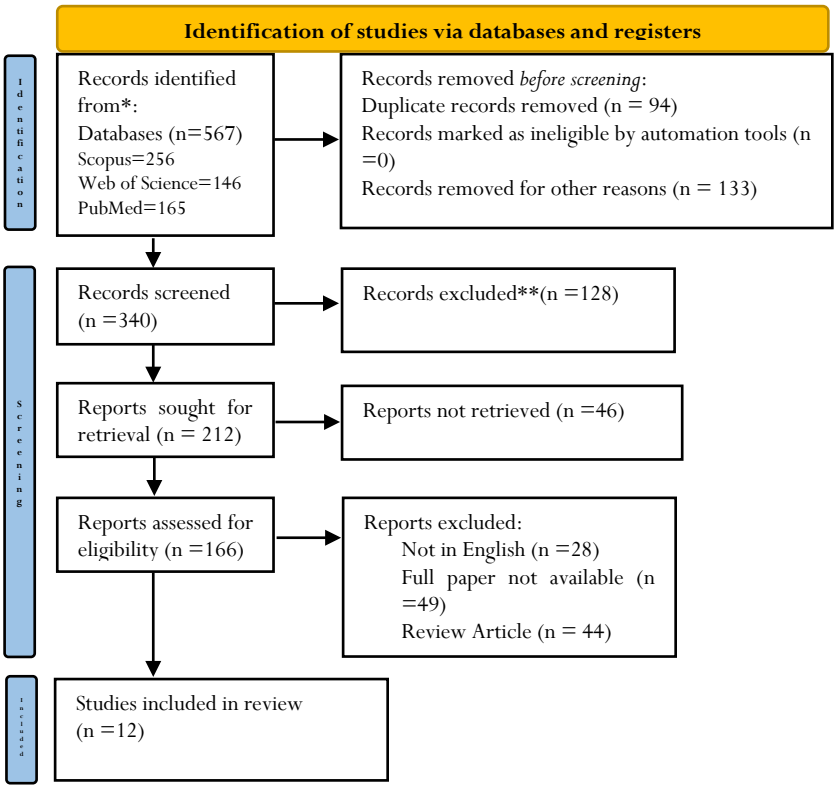

Figure 1. The Preferred Reporting Items for Systematic Review and Meta-Analyses Flow Diagram

Although the indicator that was used in these studies is the same, the amount of buffer distance of greenness that is examined is different across these studies, where there are studies which examined various distances in the range from 100m up to 3km (Wang et al., 2019; Gonzales et al., 2022; Hystad et al., 2019; Bakhtsiyarava et al., 2024) while other studies just focused on the specific distance of distance such as 250m and 1250m only (Bezold et al., 2018), 1km only (Fossa et al., 2024) and 300m only (Zhang et al., 2022; Triguero et al., 2015). Apart from that, a study used the available database from their country's yearbook to identify the greenness level in the research area (Zhou et al., 2022). Another study used ArcGIS Pro, which is software that identifies the amount of greenness (Astell-Burt et al., 2019). Furthermore, the frequency of visits and duration that citizens spend their time on the green space is also observed as an indicator of greenness exposure (Pope et al., 2018).

Table 1. Characteristics of Studies

No	Author and Year	Country	Mental Health Indicator	Green Space Indicator
1	Zhou et al., 2022	China	Instrumental Activities of Daily Life Scale (IADL)	China Urban Construction Statistical Yearbook
2	Astell-Burt et al., 2019	Australia	10-item Kessler Psychological Distress Scale	ArcGIS Pro-1.6km greenness buffer
3	Wang et al., 2019	USA	The Kessler 6 (K6) scale	Normalized difference vegetation index (NDVI)-250 m- 950 m
4	Bezold et al., 2018	USA	McKnight Risk Factor Survey (MRFS)	Normalized difference vegetation index (NDVI)-250-m and 1,250-m
5	Feng et al., 2022	Australia	10-item Kessler Psychological Distress Scale	1.6km buffer green space
6	Gonzales et al., 2022	Finland	Health and Social Support Study (HeSSup) cohort	Normalized difference vegetation index (NDVI)-100, 500, and 1000 m
7	Hystad et al., 2019	Canada	Depression-Patient Health Questionnaire-9 Anxiety- Generalized Anxiety Disorder-7scales.	Normalized difference vegetation index (NDVI)-100, 250, 500, 750, and 1000 m
8	Bakhtsiyarava et al., 2024	Mexico	Custom Questionnaire	Normalized difference vegetation index (NDVI)-250 m (or 500 m, 1, 2, or 3 km)
9	Fossa et al., 2024	USA	Composite International Diagnostic Interview-Short Form (CIDI-SF)	Normalized difference vegetation index (NDVI)-1 km buffer
10	Pope et al., 2018	UK	12-item General Health Questionnaire (GHQ)	Weekly Visit and Duration of Time Spent
11	Zhang et al., 2022	China	Face-to-face survey, physical examination, and laboratory biochemical tests & 12-items Short Form Health Survey (SF-12).	Normalized difference vegetation index (NDVI)-300m
12	Triguero et al., 2015	Spain	12-item General Health Questionnaire (GHQ)	Normalized difference vegetation index (NDVI)- 300m

Apart from that, the study results for each of the studies are tabulated in Table 2. The age range of participants varies between studies where there are studies which include teens (12-18 years old) (Wang et al., 2019; Bezold et al., 2018), Adults (20-59 years old) (Zhou et al., 2022; Astell-Burt et al., 2019; Feng et al., 2022; Gonzales et al., 2022; Hystad et al., 2019; Bakhtsiyarava et al., 2024; Pope et al., 2018; Zhang et al., 2022) and old age (More than 60) (Gonzales et al., 2022; Hystad et al., 2019; Bakhtsiyarava et al., 2024; Fossa et al., 2024; Pope et al., 2018). One study did not provide the exact age of the participants but only provided the median age of the participants, which is 50 (Triguero et al., 2015). From the age range of participants that has been studied, mental health problems affect all age range citizens. The variation in the age range of participants in the studies could produce a more comprehensive pooled value of effect in this review.

As for the type of mental health that is assessed, it varies within studies, and most of the studies that are included in this review have assessed more than one type of mental health. The type of mental health includes depression, stress, and anxiety. The most assessed mental health is depression, where a total of nine studies studied the symptoms and betterment of depression and its relation with the green space exposures. (Zhou et al., 2022; Bezold et al., 2018; Gonzales et al., 2022; Hystad et al., 2019; Bakhtsiyarava et al., 2024; Fossa et al., 2024; Pope et al., 2018; Zhang et al., 2022; Triguero et al., 2015). Second type of mental health that commonly studies are stress with a total number of five studies (Astell-Burt et al., 2019; Wang et al., 2019; Feng et al., 2022; Pope et al., 2018; Zhang et al., 2022) and lastly anxiety (Astell-Burt et al., 2019; Hystad et al., 2019; Pope et al., 2018; Zhang et al., 2022; Triguero et al., 2015).

Table 2. Summary of Study Results

No	Author and Year	Age	Sample Size	Type of Green Space	Type of Mental Health	Key Findings
1	Zhou et al., 2022	> 45	7397	Parks & Overall City Green Space	Depression	Significant betterment in the depression symptoms was discovered for every capita (m^2) increase in urban green space presence.
2	Bezold et al., 2018	12 - 18	9385	Residential Greenness		Students in the middle school, whom have a high tree density coverage in 1.25km radius are linked with a lesser chance of facing depression symptoms.
3	Gonzales et al., 2022	20-55	11794	Residential Greenness		5 years follow up on doctor diagnosed depression patients showed a reduction in depression with high residential greenness within 100-1000m, and 14 years follow up on doctor diagnosed depression patients showed reduction in depression with greenness within 100-500m.
4	Hystad et al., 2019	40-69	8144	Residential Greenness		Increase in higher tree density in the first 500m buffer distance was associated with lesser odds of depression
5	Bakhtsiyarava et al., 2024	20->60	17258	Parks		A gradually increased standard deviation of neighbourhood greenness was linked to a reduction in the participant's overall depression symptoms.
6	Fossa et al., 2024	65 +-	21611	Residential Greenness		Lesser depression symptoms were discovered for people who live in higher greenness area in the tropical climate.
7	Astell-Burt et al., 2019	> 45	46786	Residential Greenness	Stress	Higher tree canopy coverage (30% or more) was associated with lesser psychological distress stress feelings.
8	Wang et al., 2019	<18 and > 18	4538	Residential Greenness		Increase in tree density in the first 350m buffer distance from the residential area was most significant in reducing the odds on experiencing mental health symptoms.
9	Feng et al., 2022	> 45	79469	Residential Greenness		Every increment (10%) in the surrounding green space was associated with significant betterment in the mental health of the apartment residents.
10	Pope et al., 2018	20->60	578	Residential Greenness	Overall Mental Health	Better mental health is achieved for participants whom have access to green space in their area.
11	Zhang et al., 2022	> 35	1116	Parks		Lesser prevalence of mental health is associated with higher availability of green infrastructure (green roofs and street trees) in the neighbourhood.
12	Triguero et al., 2015	Median age 50	8793	Residential Greenness		Betterment in depression and anxiety symptoms was discovered in relation towards the accessibility of green space in the neighbourhood.

The results in the form of odds ratio were tabulated to calculate the standard error for all the study data. Then, a meta-analysis is performed to understand the overall pooled effect of green space on mental health. Table 3 shows the results of the studies chosen to be included in the meta-analysis. The odds ratio of all the studies discovered was less than 1, indicating that mental health symptoms is less likely to happen in the presence of increased green space exposure. Overall, this result also proves a positive association between green space and the promotion and improvement of mental health.

Table 3. Odds Ratio of Studies

Studies	Odds Ratio	Lower Limit Confidence Interval (95%)	Upper Limit Confidence Interval (95%)	Percentage Of Betterment (%)
Zhou et al., 2022	0.77	0.59	0.99	23
Astell-Burt et al., 2019	0.69	0.54	0.88	31
Wang et al., 2019	0.64	0.46	0.91	36
Bezold et al., 2018	0.81	0.68	0.97	19
Feng et al., 2022	0.87	0.79	0.96	13
Gonzales et al., 2022	0.56	0.33	0.96	44
Hystad et al., 2019	0.81	0.70	0.93	19
Bakhtsiyarava et al., 2024	0.91	0.85	0.98	9
Fossa et al., 2024	0.69	0.47	1.01	31
Pope et al., 2018	0.58	0.35	0.96	42
Zhang et al., 2022	0.88	0.79	0.99	12
Triguero et al., 2015	0.86	0.76	0.98	14

The standard error (SE) of the study was calculated using the value of log odds ratio and the log of lower limit confidence intervals (95%) following the steps from (Eq.1 – Eq.4). The results of the calculated standard errors of the studies are presented in Table 4. The standard error varies across the studies, which is understandable due to the variation in the sample size of the respective studies. The meta-analysis was performed using the generic inverse variance method (Higgins, 2013). Cochran's Q test value was 0.0844, which is more than 0.05, which shows that there is heterogeneity between the study results. To further understand the heterogeneity between the studies, the I^2 statistics were observed to be 38%, which shows moderate heterogeneity. Table 4 below shows the results obtained from the meta-analysis. The random effects were used over the fixed model due to the presence of moderate heterogeneity between studies by using Cochran's Q together with the I squared statistics test, and the number of studies for the usage of the fixed effect model which is minimum of five studies were exceeded (Murad et al., 2015; Tufanaru et al., 2015).

Table 4. Meta Analysis

Study	Estimate (Log)	Standard Error	Estimate	95% CI	Weight (%)
					Random
Zhou et al., 2022	-0.26	0.14	0.77	0.586 to 1.015	4.1
Astell-Burt et al., 2019	-0.37	0.13	0.69	0.535 to 0.891	4.65
Wang et al., 2019	-0.45	0.17	0.64	0.457 to 0.890	2.93
Bezold et al., 201	-0.21	0.09	0.81	0.679 to 0.967	8.17
Feng et al., 2022	-0.14	0.05	0.87	0.788 to 0.959	15.81
Gonzales et al., 2022	-0.58	0.27	0.56	0.330 to 0.950	1.24
Hystad et al., 2019	-0.21	0.07	0.81	0.707 to 0.930	11.29
Bakhtsiyarava et al., 2024	-0.09	0.03	0.91	0.862 to 0.969	21.57
Fossa et al., 2024	-0.37	0.20	0.69	0.467 to 1.022	2.18
Pope et al., 2018	-0.54	0.26	0.58	0.350 to 0.970	1.33
Zhang et al., 2022	-0.13	0.06	0.88	0.781 to 0.988	13.36
Triguero et al., 2015	-0.15	0.06	0.86	0.765 to 0.968	13.36
Total (random effects)	-0.18	0.03	0.83	0.784 to 0.884	100

Test for heterogeneity

Q	17.8804
DF	11
Significance level	P = 0.0844
I^2 (inconsistency)	38.48%
95% CI for I^2	0.00 to 68.88

From the results in Table 4, the weights for each of the studies are presented, and the studies were weighted according to its inverse variance effect of estimates where more extensive studies, with lesser standard error, were given more weight to reduce the effect of uncertainty in the overall estimated effect. For further analysis, a forest plot is plotted to understand the overall combined effect of the estimate in a systematic way. Figure 2 below shows the forest plot of the meta-analysis. The forest plot shows that most studies conveyed results less than 1. This indicates less likelihood for mental health problems for citizens who have green space exposure. Generally, increased urban green spaces have a positive impact on improving the mental health of the citizens.

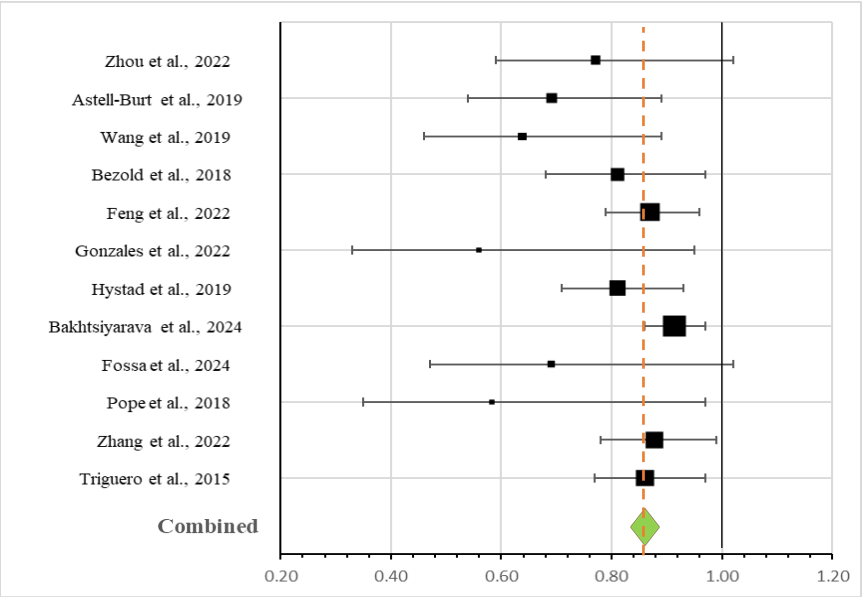

Figure 2. Forest Plot

The combined effect from the meta-analysis and the forest plot shows a significance value of pooled effect at 0.83 with a lower confidence interval of 95% at 0.78 and an upper confidence interval of 95% at 0.88 [OR (95%CI): 0.83 (0.78–0.88)]. This result indicates that there is a betterment in terms of mental health, including depression, stress, and anxiety, by 17%, which reflects the results from the studies that are included in this review and validates the fact that green space exposure is one of the essential components in daily life that needs to be exposed for mental health stabilisation and improvement.

4. Discussions

Holistically, the overall results show the positive effect of green space towards mental health and getting green exposure could be beneficial for citizens to enjoy the benefits of it in terms of improving mental health conditions. For the citizens who do not experience any mental health symptoms, it could be treated as a place to seek rejuvenation and relaxation to recover from the stresses of life. The 17% betterment of the mental health of the citizens also could vary according to the quality of the green space attributes involved in the efficiency of the green spaces. The attributes involved act a catalyst in enhancing the quality of benefits provided by green spaces. The various way of identifying and understanding green space and mental health indicators in the reviewed studies explains how a person can enjoy green space exposures in various ways. From the list of study results, the similarities that can be discovered is that higher density of greenness and closer distance to the green spaces from the neighbourhood have advantage towards depression and stress. On the other hand, better accessibility feature to the green spaces have shown positive affects not only specifically towards certain type of mental health but to the overall mental health of a person, which includes depression, anxiety, and stress. Although the type of green space varies across studies, the focus on the enhancement of mental health symptoms can discovered across all studies showing that green space has high capability in improving mental health of citizens. The interest on discovering the enhancing benefits of attributes such as density of greenness, distance of green space and the accessibility to the green space are vital in implementing green open space for the public for the mental and physical health benefits. Generally, having a greener environment filled with plants and street trees at around 100m up to 1.25 km in their residential neighbourhood could improve all three stated mental health symptoms.

Apart from the availability of green space in the neighbourhood, there are also concerns regarding the accessibility of green spaces in the areas of research. Although there is availability of green spaces in the area, there are some of them which are not accessible, which makes it difficult and demotivating for the residents in the neighbourhood to visit these places to enjoy the benefits that it offers. The improvement of mental health symptoms was higher for citizens who have easy accessibility to the green space in their neighbourhood environment. This

shows that not only having green space exposure is essential, but having accessibility to access the green space plays a role as well in the efficiency of the green space.

In addition, the size of the green space also matters where the bigger size provides better aesthetics and view that increases the efficiency of green spaces in stabilising mental health condition. Bigger size of green space increases its capability to cater and occupy many citizens at a time comfortably and provide a platform for citizens to perform physical activities which can help to decrease stress and interact between each other which helps with depression and anxiety symptoms. This is also closely related to the amount of tree coverage as well, which is the density of greens on the green space. Higher tree density in the green space is supported by increased green space efficiency in improving mental health.

Mental health is an important factor that should be taken care of together with physical health and should be neglected to live a quality and peaceful life (Kmietowicz, 2005). Poor mental health conditions affect the efficiency of a person in carrying out their daily chores and decrease their productivity in their daily lives. All age range citizens are facing mental health symptoms these days. Teens are experiencing mental health symptoms as early as from the middle school. On the other hand, people who are in the old age category (more than 60 years old) are also facing these symptoms. In terms of green space exposure, these conditions can be explained that people in all age categories is facing mental health problems around the world and it can be concluded that the benefits that the green space portrays is needed for all age groups despite specifically aiming to the people whom are in their working age.

In terms of time and progress of mental health, the green space benefits do not come with one day exposure nor does not have any limit range on its benefits towards its promotion on the mental health. The green space exposure has it is compounding benefits if it is experienced daily, weekly, or monthly. By looking at the benefit over the years, one of the studies compared the data on depression symptoms of the participants in a 5 years and 14 years follow up together with their greenness exposures (Gonzales et al., 2022). The study reported that there is a significant improvement in depression symptoms over the years. Overall, green space existence in the residential and workplace is beneficial for all citizens to improve their mental health which concurrently enables us to be feel relaxed and able us to be fully productive.

The were several limitations that was identified in the process of completing this review. Firstly, there was a presence of moderate heterogeneity in the studies due to the difference in places, type of green space studied and number of populations studied in the selected studies. Secondly, only studies that use multilevel logistic regression were selected due to the requirement to retrieve the results in the form of odds ratio to calculate the pooled effect. There might also be a presence of bias in the results as some studies used self-reported health outcomes and not clinically certified mental health status of the participants in calculating the odds ratio. Despite the limitations, this review gives an overall view and a clear understanding regarding the efficiency of green space towards mental health improvement using the latest results published in these recent years throughout the world.

5. Conclusions

In conclusion, this review presents insightful information regarding the efficiency of green space in improving the mental health of citizens in all age categories. Accessible, bigger size and higher tree canopy covered green spaces availability in the 1km buffer of the residential neighbourhood have benefits in improving the mental health of the citizens. Based on this review, the results suggests that green space implementation in urban area has high proficiency in improving the mental health of citizens. The stakeholder and law makers in the built environment industry could use this review information as a tool of guide and prove to portray the importance of green spaces to create and revise public health policy with emphasising the planning and supply of more green spaces for the purpose of public mental health. This review is significant to the local and national governments in every country, to emphasize providing the availability of green spaces in the streets and mainly in the residential neighbourhoods, such as parks and green roofs to ensure the overall mental wellbeing of the citizens and to improve mental symptoms such as stress, depression, and anxiety. Developers could also take inspiration from this study to increase the amount of greenness available in their upcoming projects and concurrently market it using this study results to show the benefits of having increased green space exposure towards betterment on mental health. All citizens should consider visiting green spaces either daily, weekly, or monthly to maintain a balanced lifestyle with equilibrium state of physical and mental health.

The current review indicates that there is a positive relationship between green spaces and mental health across the countries which portrays the social benefits of green space. However, more future medical research is needed to evaluate and specify the benefits of green space in improving mental health by taking into consideration of the past and present mental health medical records of citizens and study the effect of nature exposure towards the changes in their mental health results through a specific period. Apart from that, further researchers can focus on the economic and environmental benefits of green space in relation with mental health to support the decision making of authorities and enhance the current state of knowledge regarding the effectiveness of green space implementation.

Acknowledgements

The authors would like to express their sincere gratitude to their family, colleagues and the reviewers that played important roles in the completion of this study

References

Akpınar, Abdullah & Barbosa-Leiker, Celestina & Brooks, Kerry. (2016). Does green space matter? Exploring relationships between green space type and health indicators. *Urban Forestry & Urban Greening. 20*. 407–418. http://dx.doi.org/10.1016/j.ufug.2016.10.013

Aram, F., Higueras García, E., Solgi, E., & Mansournia, S. (2019). Urban green space cooling effect in cities. *Heliyon, 5(4)*, e01339. https://doi.org/10.1016/j.heliyon.2019.e01339

Astell-Burt, T., & Feng, X. (2019). Association of Urban Green Space with Mental Health and General Health Among Adults in Australia. *JAMA network open, 2(7), e198209*.https://doi.org/10.1001/jamanetworkopen.2019.8209

Azis, S. S. A., & Zulkifli, N. A. A. (2021). Green roof for sustainable urban flash flood control via cost benefit approach for local authority. *Urban forestry & urban greening, 57, 126876*. https://doi.org/10.1016/j.ufug.2020.126876

Bakhtsiyarava, Maryia & Ju, Yang & Moran, Mika & Rodriguez, Daniel & Dronova, Iryna & Delclòs-Alió, Xavier & Moore, Kari & Castillo-Riquelme, Marianela & Anza-Ramirez, Cecilia. (2024). Associations between urban greenspace and depressive symptoms in Mexico's cities using different greenspace metrics. *Applied Geography. 164. 103219*.https://doi.org/10.1016/j.apgeog.2024.103219

Bezold, C. P., Banay, R. F., Coull, B. A., Hart, J. E., James, P., Kubzansky, L. D., Missmer, S. A., & Laden, F. (2018). The Association Between Natural Environments and Depressive Symptoms in Adolescents Living in the United States. *The Journal of adolescent health : official publication of the Society for Adolescent Medicine, 62(4), 488–495*.https://doi.org/10.1016/j.jadohealth.2017.10.008

Bhugra, D., Till, A., & Sartorius, N. (2013). What is mental health? *The International journal of social psychiatry, 59(1)*, 3–4. https://doi.org/10.1177/0020764012463315

Bojic, Sandra. (2018). Organic Agriculture Contribution to the Rural Tourism Development in the North of Montenegro. *Journal of Economics and Business. 1. 222-233*.http://dx.doi.org/10.31014/aior.1992.01.03.22

Carrus, G., Scopelliti, M., Lafortezza, R., Colangelo, G., Ferrini, F., Salbitano, F., ... & Sanesi, G. (2015). Go greener, feel better? The positive effects of biodiversity on the well-being of individuals visiting urban and peri-urban green areas. *Landscape and urban planning, 134, 221-228.* https://doi.org/10.1016/j.landurbplan.2014.10.022

Chiesura, Anna. (2004). The Role of Urban Parks for the Sustainable City. *Landscape and Urban Planning. 68. 129-138*. http://dx.doi.org/10.1016/j.landurbplan.2003.08.003

Croucher, K. L., Myers, L., & Bretherton, J. (2008). The Links Between Green Space and Health: A Critical Literature Review. *Greenspace Scotland*.

Coronel Santos, Maday & Rodríguez Macías, Juan. (2022). Integral definition and conceptual model of mental health: Proposal from a systematic review of different paradigms. *Frontiers in Sociology. 7.* http://dx.doi.org/10.3389/fsoc.2022.978804

Dannenberg, A. L., Jackson, R. J., Frumkin, H., Schieber, R. A., Pratt, M., Kochtitzky, C., & Tilson, H. H. (2003). The impact of community design and land-use choices on public health: a scientific research agenda. *American journal of public health, 93(9), 1500–1508*.https://doi.org/10.2105/ajph.93.9.1500

Demyttenaere, K., Bruffaerts, R., Posada-Villa, J., Gasquet, I., Kovess, V., Lepine, J. P., Angermeyer, M. C., Bernert, S., de Girolamo, G., Morosini, P., Polidori, G., Kikkawa, T., Kawakami, N., Ono, Y., Takeshima, T., Uda, H., Karam, E. G., Fayyad, J. A., Karam, A. N., Mneimneh, Z. N., ... WHO World Mental Health Survey Consortium (2004). Prevalence, severity, and unmet need for treatment of mental disorders in the World Health Organization World Mental Health Surveys. *JAMA, 291(21), 2581–2590*.https://doi.org/10.1001/jama.291.21.2581

Feng, X., Toms, R., & Astell-Burt, T. (2022). The nexus between urban green space, housing type, and mental health. *Social psychiatry and psychiatric epidemiology, 57(9), 1917–1923*.https://doi.org/10.1007/s00127-022-02266-2

Fossa, A. J., D'Souza, J., Bergmans, R., Zivin, K., & Adar, S. D. (2024). Residential greenspace and major depression among older adults living in urban and suburban areas with different climates across the United States. *Environmental research, 243, 117844*.https://doi.org/10.1016/j.envres.2023.117844

Fuller, R. A., Irvine, K. N., Devine-Wright, P., Warren, P. H., & Gaston, K. J. (2007). Psychological benefits of greenspace increase with biodiversity. *Biology letters, 3(4), 390–394*. https://doi.org/10.1098/rsbl.2007.0149

Galderisi, S., Heinz, A., Kastrup, M., Beezhold, J., & Sartorius, N. (2015). Toward a new definition of mental health. *World psychiatry : official journal of the World Psychiatric Association (WPA), 14(2), 231–233.* https://doi.org/10.1002/wps.20231

Gonzales-Inca, C., Pentti, J., Stenholm, S., Suominen, S., Vahtera, J., & Käyhkö, N. (2022). Residential greenness and risks of depression: Longitudinal associations with different greenness indicators and spatial scales in a Finnish population cohort. *Health & place, 74, 102760.* https://doi.org/10.1016/j.healthplace.2022.102760

Grahn, P. and Stigsdotter, U.A. (2003) Landscape Planning and Stress. *Urban Forestry & Urban Greening, 2, 1-18*.https://doi.org/10.1078/1618-8667-00019

Higgins JPT, Green S. Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]. *The Cochrane Collaboration, 2011*. Available fromwww.handbook.cochrane.org.

Higgins, J. P., & Green, S. (Eds.). (2008). Cochrane handbook for systematic reviews of interventions.

Higgins, J. P., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *BMJ (Clinical research ed.), 327(7414), 557–560*.https://doi.org/10.1136/bmj.327.7414.557

Hystad, P., Payette, Y., Noisel, N., & Boileau, C. (2019). Green space associations with mental health and cognitive function: Results from the Quebec CARTaGENE cohort. *Environmental epidemiology (Philadelphia, Pa.), 3(1), e040*.https://doi.org/10.1097/EE9.0000000000000040

Ihlebæk, C., Aamodt, G., Aradi, R., Claussen, B., & Thorén, K. H. (2018). Association between urban green space and self-reported lifestyle-related disorders in Oslo, Norway. *Scandinavian journal of public health, 46(6), 589–596.* https://doi.org/10.1177/1403494817730998

James, Philip & Tzoulas, Konstantinos & Adams, Mags & Barber, A. & Box, John & Breuste, Jürgen & Elmqvist, Thomas & Frith, Mathew & Gordon, Chris & Greening, K.L. & Handley, J. & Haworth, S. & Kazmierczak, Aleksandra & Johnston, Mark & Korpela, Kalevi & Moretti, Marco & Niemelä, Jari & Pauleit, Stephan & Roe, Maggie &

Ward Thompson, Catharine. (2009). Towards an integrated understanding of green space in the European built environment. *Urban Forestry & Urban Greening. 8. 65-75.*http://dx.doi.org/10.1016/j.ufug.2009.02.001

Kitchenham, B., & Charters, S. (2007). Guidelines for performing systematic literature reviews in software engineering.

Kmietowicz Z. (2005). Mental health should have same priority as physical health. *BMJ (Clinical research ed.), 330(7505), 1408.* https://doi.org/10.1136/bmj.330.7505.1408-a

Lederbogen, F., Haddad, L., & Meyer-Lindenberg, A. (2013). Urban social stress--risk factor for mental disorders. The case of schizophrenia. *Environmental pollution (Barking, Essex : 1987), 183, 2–6.* https://doi.org/10.1016/j.envpol.2013.05.046

Ma, B., Zhou, T., Lei, S. et al. Effects of urban green spaces on residents' well-being. *Environ Dev Sustain 21, 2793–2809 (2019).* https://doi.org/10.1007/s10668-018-0161-8

Morita, E., Fukuda, S., Nagano, J., Hamajima, N., Yamamoto, H., Iwai, Y., Nakashima, T., Ohira, H., & Shirakawa, T. (2007). Psychological effects of forest environments on healthy adults: Shinrin-yoku (forest-air bathing, walking) as a possible method of stress reduction. *Public health, 121(1), 54–63.* https://doi.org/10.1016/j.puhe.2006.05.024

Murad M, & Montori V.M., & Ioannidis J.A., & Prasad K, & Cook D.J., & Guyatt G Fixed-effects and random-effects models. Guyatt G, & Rennie D, & Meade M.O., & Cook D.J.(Eds.), (2015*) Users' Guides to the Medical Literature: A Manual for Evidence-Based Clinical Practice, 3rd ed. McGraw-Hill Education*.https://jamaevidence.mhmedical.com/content.aspx?bookid=847&sectionid=69031503

Najihah, Amal & Abdullah, Saiful. (2019). Developing Urban Green Space Classification System Using Multi-Criteria: The Case of Kuala Lumpur City, Malaysia. *Journal of Landscape Ecology. 12. 16-36.* http://dx.doi.org/10.2478/jlecol-2019-0002

Nath, Tapan Kumar, Zhe Han, Shawn Sim, and Lechner, Alexander Mark (2018). Urban green space and well-being in Kuala Lumpur, Malaysia. *Urban Forestry and Urban Greening 36 34-41.* https://doi.org/10.1016/j.ufug.2018.09.013

Nero, B. F., Callo-Concha, D., Anning, A., & Denich, M. (2017). Urban green spaces enhance climate change mitigation in cities of the global south: the case of Kumasi, Ghana. *Procedia engineering, 198, 69-83.* https://doi.org/10.1016/j.proeng.2017.07.074

Nutsford, D., Pearson, A. L., & Kingham, S. (2013). An ecological study investigating the association between access to urban green space and mental health. *Public health, 127(11), 1005–1011.* https://doi.org/10.1016/j.puhe.2013.08.016

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., McGuinness, L. A., … Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ (Clinical research ed.)*, *372*, n71.https://doi.org/10.1136/bmj.n71

Peen, J., Schoevers, R. A., Beekman, A. T., & Dekker, J. (2010). The current status of urban-rural differences in psychiatric disorders. *Acta psychiatrica Scandinavica, 121(2), 84–93.*https://doi.org/10.1111/j.1600-0447.2009.01438.x

Pope, D., Tisdall, R., Middleton, J., Verma, A., van Ameijden, E., Birt, C., Macherianakis, A., & Bruce, N. G. (2018). Quality of and access to green space in relation to psychological distress: results from a population-based cross-sectional study as part of the EURO-URHIS 2 project. *European journal of public health, 28(1), 35–38.* https://doi.org/10.1093/eurpub/ckv094

Szumilas M. (2010). Explaining odds ratios. *Journal of the Canadian Academy of Child and Adolescent Psychiatry = Journal de l'Academie canadienne de psychiatrie de l'enfant et de l'adolescent, 19(3), 227–229.* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2938757/

Taylor, L., & Hochuli, D. F. (2017). Defining greenspace: Multiple uses across multiple disciplines. *Landscape and urban planning, 158, 25-38.*https://doi.org/10.1016/j.landurbplan.2016.09.024

Tenny, S., & Hoffman, M. R. (2017). Odds ratio.Available from:https://www.ncbi.nlm.nih.gov/books/NBK431098/

Triguero-Mas, M., Dadvand, P., Cirach, M., Martínez, D., Medina, A., Mompart, A., Basagaña, X., Gražulevičienė, R., & Nieuwenhuijsen, M. J. (2015). Natural outdoor environments and mental and physical health: relationships and mechanisms. *Environment international, 77, 35–41.* https://doi.org/10.1016/j.envint.2015.01.012

Tsai, W. L., McHale, M. R., Jennings, V., Marquet, O., Hipp, J. A., Leung, Y. F., & Floyd, M. F. (2018). Relationships between Characteristics of Urban Green Land Cover and Mental Health in U.S. Metropolitan Areas. *International journal of environmental research and public health, 15(2), 340.* https://doi.org/10.3390/ijerph15020340

Tufanaru, C., Munn, Z., Stephenson, M., & Aromataris, E. (2015). Fixed or random effects meta-analysis? Common methodological issues in systematic reviews of effectiveness. *International journal of evidence-based healthcare, 13(3), 196–207.*https://doi.org/10.1097/XEB.0000000000000065

Wang, P., Meng, Y. Y., Lam, V., & Ponce, N. (2019). Green space and serious psychological distress among adults and teens: A population-based study in California. *Health & place, 56, 184–190.* https://doi.org/10.1016/j.healthplace.2019.02.002

Wilkerson, M. L., Mitchell, M. G., Shanahan, D., Wilson, K. A., Ives, C. D., Lovelock, C. E., & Rhodes, J. R. (2018). The role of socio-economic factors in planning and managing urban ecosystem services. *Ecosystem Services, 31, 102-110.*https://doi.org/10.1016/j.ecoser.2018.02.017

Wood, L., Hooper, P., Foster, S., & Bull, F. (2017). Public green spaces and positive mental health - investigating the relationship between access, quantity and types of parks and mental wellbeing. *Health &place, 48, 63* https://doi.org/10.1016/j.healthplace.2017.09.002

Yuliani, Sri & Hardiman, Gagoek & Setyowati, Erni. (2020). Green-Roof: The Role of Community in the Substitution of Green-Space toward Sustainable Development. *Sustainability. 12. 1429.* http://dx.doi.org/10.3390/su12041429

Zhang, J., Cui, J., Astell-Burt, T., Shi, W., Peng, J., Lei, L., Xin, X., Zhang, J., Feng, X., Jiang, Y., & Ma, J. (2022). Weekly green space visit duration is positively associated with favorable health outcomes in people with hypertension: Evidence from Shenzhen, China. *Environmental research, 212(Pt B), 113228.* https://doi.org/10.1016/j.envres.2022.113228

Zhao, Juanjuan & Ouyang, Zhiyun & Zheng, Hua & Zhou, Weiqi & Wang, Xiaoke & Xu, Weihua & Ni, Yongming. (2010). Plant species composition in green spaces within the built-up areas of Beijing, China. *Plant Ecology. 209. 189-204.* http://dx.doi.org/10.1007/s11258-009-9675-3

Zhou, R., Zheng, Y. J., Yun, J. Y., & Wang, H. M. (2022). The Effects of Urban Green Space on Depressive Symptoms of Mid-Aged and Elderly Urban Residents in China: Evidence from the China Health and Retirement Longitudinal Study. *International journal of environmental research and public health, 19(2), 717.* https://doi.org/10.3390/ijerph19020717