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Gender and sex differences in urban greenness' mental health benefits: A systematic review

Marta-Beatriz Fernández Núñez [a], Lia Campos Suzman [a], Roser Maneja [b,c], Albert Bach [b], Oriol Marquet [c], Isabelle Anguelovski [a,d,e,f], Pablo Knobel [a,b,g,*]

[a] Environmental Science and Technology Institute (ICTA), Universitat Autònoma de Barcelona, Spain
[b] Environment and Human Health Laboratory (EH^2 Lab), Forest Science and Technology Center of Catalonia, Ctra. de St. Llorenç de Morunys, Km 2, Solsona, 25280, Spain
[c] Geography Department, Universitat Autònoma de Barcelona, B Building, UAB Campus, Bellaterra (Cerdanyola del Vallès), Barcelona, Spain
[d] Catalan Institution for Research and Advanced Studies (ICREA), Spain
[e] Medical Research Institute Hospital del Mar (IMIM), 08003, Barcelona, Spain
[f] Barcelona Laboratory for Urban Environmental Justice and Sustainability, Barcelona, Spain
[g] Icahn School of Medicine at Mount Sinai, Department of Environmental Medicine and Public Health, New York, NY, USA

1. Introduction

Mental health disorders have been rising globally in recent years (Bradbury, 2020). Among other factors, the rise of depressive disorders may be linked to the disconnection from natural environments in parallel with an increase in urbanisation (White et al., 2013). The context of the COVID-19 pandemic and related confinements and travel restrictions might also have affected people's ability to be in closer contact with nature (Ribeiro et al., 2021; Soga et al., 2021; Lõhmus et al., 2021; Pouso et al., 2021). Yet, a broad range of studies have demonstrated a beneficial relationship between urban greenness (e.g., parks) and mental health, including in the form of social cohesion and reduced stress-related disorders (Jennnings and Bamkole, 2019; Bell et al., 2014; Webster et al., 2018). Thus, prompting many cities to design ambitious greenness and re-naturing interventions and enact a green, healthy city vision (Andersson et al., 2019; Ruijsbroek et al., 2017; Hunter et al., 2019). The increase in people living in urban areas stresses the importance of having proximate access to urban greenness for mental health benefits in neighbourhood environments (Albin et al., 2012; White et al., 2013).

However, few studies have examined whether mental health benefits associated with urban greenness are equally positively impacting women and men. On the one hand, women are more likely to suffer mental health conditions, with women estimated to be two times more likely to suffer from depression than men Freeman and Freeman (2013). On the other, women and men have been shown to perceive and use urban greenness differently. For example, even if both use the same space simultaneously, women seem to be more selective and considerate in choosing urban green spaces (Topcu, 2019). Derose et al. (2017) found that women, compared to men, reported fewer visits and shorter durations to their residential park, which also resulted in a lower probability than men to exercise. Fontán-Vela et al. (2021) results were consistent with Derose et al. (2017) findings: women showed lower physical activity levels compared to men in parks. The study pointed out that one reason for this is because female residents suffer more often from different types of violence in the streets. This makes them more discouraged from using urban greenness. In addition, crime and perceived safety have been found to influence park use, especially among women and girls (Marquet et al., 2019; Derose et al., 2017; Fontán-Vela et al., 2021). Given the importance that urban greenness can have on people's health, crimes and safety perceptions may thus affect health, since they are often a barrier to park use, especially for girls (Marquet et al., 2019). Girls seem indeed more significantly impacted by crime than boys (Marquet et al., 2019). In short, the impact of urban greenness on mental health may differ concerning sex and gender (Bolte et al., 2019).

Past studies on those topics generally either use "sex" or "gender" in an indiscriminate or unsystematic way. However, sex and gender have different meanings and connotations. The term sex relates to the biological dimension, individuals classified based on their reproductive function as females and males. Gender refers to the social dimensions, it is a social category related to the way societies see women and men, including the power structures around them (Sullivan, 2020), and how both see themselves. Using the two terms interchangeably is problematic because many of the differences between the sexes are often due to social hierarchical structures rather than biological traits (Bolte et al.,

* Corresponding author. Icahn School of Medicine at Mount Sinai, 1 Gustave L. Levy Place, Box 1057, New York, NY, 10029, USA.
E-mail address: Pablo.knobel@mssm.edu (P. Knobel).

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2019 and Sullivan, 2020). Thus, sex and gender inequalities and differences in environmental mental health evidence have not been adequately contemplated and should be taken into account on their own (Hunting et al., 2018) in setting up study designs and in analysis and interpretation of results. Although there has been a growing concern about integrating gender and sex perspectives into environmental mental health research, they need to be integrated comprehensively and systematically (Bolte et al., 2019). In this paper, we will emphasise both biological traits and the social dimensions shaping differences in mental health benefits when discussing associated results, to avoid inaccuracies and misinterpretations. However, in the studies we identify as relevant for our paper, both sex and gender are examined and discussed only in binary terms.

This paper will seek to answer the following questions: How are gender and sex used in the literature on the association between urban green and mental health? To what extent and how does urban greenness unequally distribute mental health benefits in women and females compared to men and males.

2. Materials & methods

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for systematic reviews (Table A.1).

2.1. Search method

We conducted this systematic review through searches in three different electronic journal databases: Scopus; Web of Science, and PubMed throughout March 2021. We used Scopus, Web of Science, and PubMed as we determined that these three databases guaranteed adequate and efficient coverage within the search review. Scopus and Web of Science have been the two most widely used databases for bibliometric analysis (Singh et al., 2021). These two databases also supply more sophisticated tools for measuring scholarly publication trends (Cavacini, 2015). Additionally, PubMed's resources have made the database one of the most biomedical resources globally used (Williamson and Minter, 2019). Hence, we used it for its ability to find relevant articles related to medical literature, such as in the mental health field. We found that these databases provided better quality and accuracy of bibliographic records compared to others.

The applied search comprised three sets of keywords: first regarding urban greenness, including different terms related to greenness, urban public spaces and natural environments; second, regarding health differences by gender and sex, including modification, interaction and stratification; and third, regarding mental health outcomes, including common mental health disorders and social health. The complete breakdown of search terms can be found in Table A.2.

2.2. Eligibility criteria

We only included original research articles published in peer-review journals written in English. We also included both mental health mediators and outcomes to understand the complex relationship between them better. The articles included had to mention mental health outcomes which all had to be linked to urban greenness associated with gender and sex differences. In addition, we excluded studies using virtual environments as those might compromise the consistency and accuracy of the results.

2.3. Selection process

Search results were exported to and analysed in Rayyan. Rayyan is an Intelligent Systematic Review program that eases collaboration to help scientific findings amongst a global research community (Hammady et al., 2016). Duplicates were eliminated using the Rayyan build-in function. Subsequently, two authors (LC, MF) screened all the literature search results: first by title and then by abstracts according to the eligibility criteria. Later, the reviewers analysed the full texts of the articles against relevance for the literature review.

The snowball method was used to expand findings after the systematic search to ensure a more comprehensive selection of papers. In addition, one reviewer (LC) analysed the reference list of all included literature to select any other relevant paper that was not included in the initial database results.

2.4. Data extraction

We then extracted information about each selected article. The information extracted included the number of participants admitted in the studies, the location, the mental health outcomes assessed, how the authors measured it, and how the studies measured urban greenness exposure (e.g., surrounding greenness, greenness quality, self-reported greenness, etc.). Additionally, we also extracted data concerning gender and sex differences. We looked at how the terms gender and sex were operationalised and how the other terms associated with them were used (women and females; men and males).

3. Results

3.1. Article selection

The systematic search identified 336 papers after removing duplicates. Subsequently, based on screening of the titles and abstracts, we analysed 26 papers in full against the inclusion criteria. We determined that nine of them were relevant to the systematic review. In addition, we found seven further studies using the snowball method. In total, we analysed 16 articles for this systematic review (Fig. 1).

3.2. Overall study characteristics and measurements

From the studies included, 68.7% were cross-sectional, and 31.25% were longitudinal studies. All studies were published between 2005 and 2020. The sample size varied extensively, ranging from 13 to 943,027 participants. The focus population ranged from children to the elderly (age 8 to 87). However, 9 of the studies only focused on adults. In addition, the majority of the studies were conducted in Europe (n = 9), followed by Asia (n = 6). The remaining study was carried out in Jamaica (Table 1).

Half of the articles measured specific mental health outcomes with qualitative measures (questionnaires including self-questionnaire, interviews, and observations). The other eight papers used either specific tests or longitudinal data from national registers, such as national-level surveys and logs in national databases.

3.2.1. Urban greenness exposure measurement

Table 1 shows three categories (surrounding greenness, greenness quality, and self-reported greenness) regarding urban greenness exposure measurement identified in the included studies.

Most of the studies measured urban greenness subjectively. Out of the nine studies that did so, seven of the studies measured greenness quality through site observations, park soundscapes, and interviews of the participants regarding perceptions, use, and experiences of the greenness selected. The rest of the studies used self-reports concerning time spent, usage, and perceived quality of greenness near participants' residential addresses.

Additionally, out of the seven studies which measured urban greenness objectively, three of them used the Normalized Difference Vegetation Index (NDVI) to analyse the surrounding greenness of a participant's residential address. Other studies measured greenness exposure as proximity to greenness from home addresses. For instance, Koohsari et al. (2018) and Bos et al. (2016) used specific buffers: 800 m

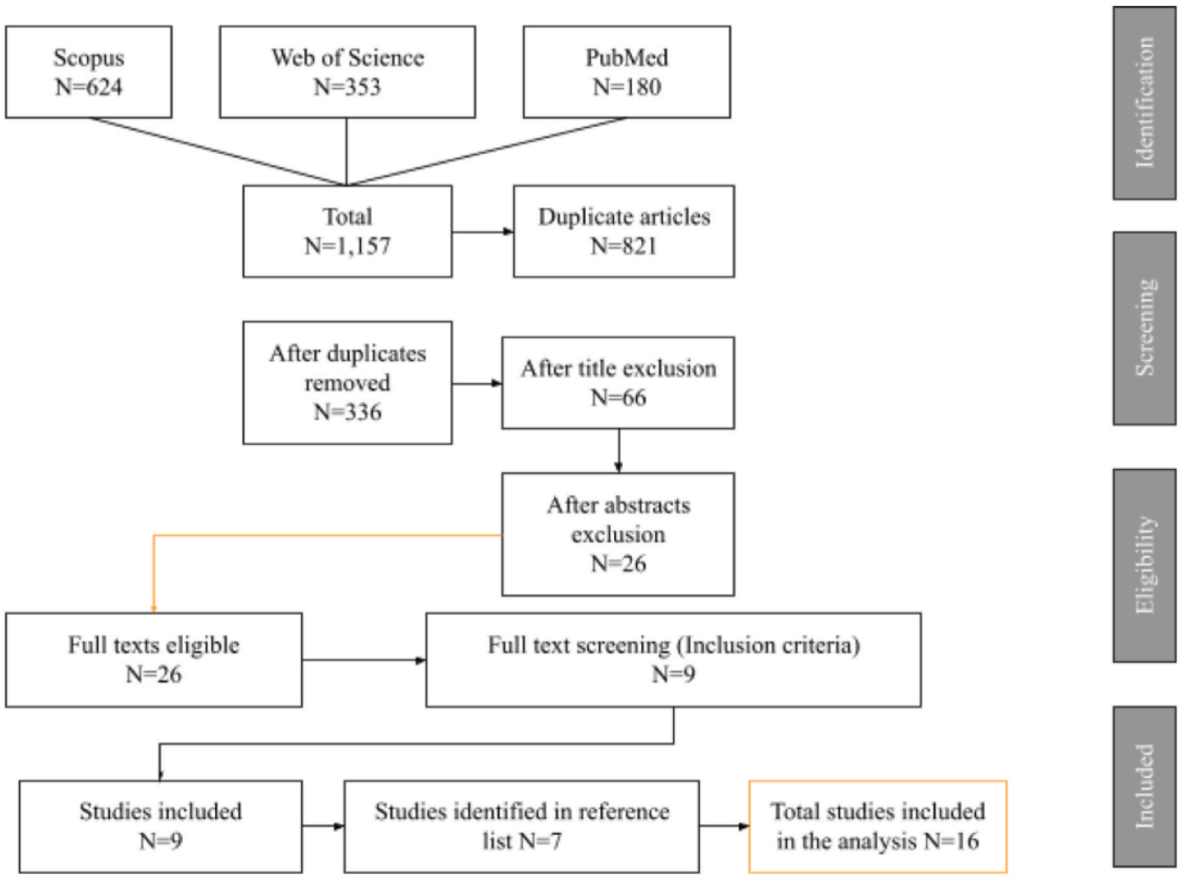

Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)-flow diagram of the selection process.

and 1600 m and 1 km and 3 km, respectively. In addition, Annerstedt et al. (2012) used grids of land cover maps to measure proximity exposure, and Roe et al. (2013) used the percentage of identified green areas in the Census Area Statistics related to the participant's home address.

3.3. Use of gender and sex in the studies

None of the articles reflected upon the possible gender bias there might exist when measuring the different mental health outcomes nor did they define the terms gender and/or sex. However, one study (Currie et al., 2016) explained why they used the terms the way they did. The study drew upon the benefits of greenspace not being solely a reflection of biological female and male. Therefore, they explored gender experiences associated with green space from a perspective in which gender and sex are blurry. The study used the term gender instead of sex to highlight gender constraints within social interactions.

All papers examined sex and gender only within the known binarity. Most of the studies (N = 9) only assessed gender; four of the studies examined both and only three assessed sex. Only seven of the studies used the terms correctly, meaning that the factor examined (sex or gender) corresponded to the correct associated terms (female/male or women/men). The rest misused the terms female and male and women and men: many studies presented results where they stratified participants by gender but used the terms females and males, when these terms only represent the biological dimension of a person.

In our study, we will use women or females depending on what the studies have examined gender or sex. Thus, the terminology we will use will not necessarily be the same as what the texts choose to use. Additionally, when the participants of the studies are children, our terminology will be girls or boys for when they have examined gender differences and young females or young males for when they have assessed sex difference. Furthermore, when referring to a paper that has studied both gender and sex, we will refer to the participants as women/females or men/males, to emphasise that both dimensions were assessed. The same terminology will be used when referring to many papers that have assessed gender and sex separately.

3.4. Mental health

The most common mental health disorders and illnesses studied were depression and stress (also referred to as "psychological stress" in two studies). However, other mental health outcomes were also examined.

All studies found at least one difference in the association between urban greenness and mental health when comparing women and men. However, there are mixed results. Whitley et al. (2005) was the only study in which there were no apparent sex differences. One study (Raggi et al., 2014) presented minimal differences between women/females and men/males. In general, there seem to be sex and gender differences: Seven studies (Koohsari et al., 2018; Bos et al., 2016; Sarkar et al., 2018; Helbich et al., 2020; Roe et al., 2013; Ullah et al., 2020; Annerstedt et al., 2012) showed more beneficial mental health outcomes towards females related to urban greenness. Three studies (Dadvand et al., 2018; Bahriny and Bell, 2020; Toutakhane, 2018) reported more beneficial mental health outcomes towards men/males and highlighted safety concerns and socio-cultural aspects as a key factor influencing only women/-female participants, which points to gender differences more than sex differences. The remaining four studies (Engemann et al., 2019; Mullings et al., 2013; Shu and Ma, 2020; Currie et al., 2016) did not have a clear beneficiary as the studies suggested; it depends on other variables (e.g., the type of mental health illness).

Table 1
Key characteristics of the articles.

Mental health outcomes							
Citations	Sample Size	Location	Typology used (Gender/ Sex)	Terminology used (women/men or female/male)	Gender and sex measure[a]	Greenness measure	Gender & sex Results[b]
Koohsari, M.J. et al., 2018	328	Japan	Gender	Women/men	Self-administered questionnaire	Surrounding greenness	Beneficial effects of built environments were more pronounced in women
Engemann, K. et al., 2019	943,027	Denmark	Gender	No mention of either	Civil Registration	Surrounding greenness	Different mental health illnesses are more pronounced depending on gender
Mullings, J.A. et al., 2013	2,848	Jamaica	Both	Both	Survey	Greenness quality	Variation in urban qualities/attributes affect women and men's and females' and males' symptomatology differently.
Bos, E. et al., 2016	4924	Netherlands	Gender	Both	Questionnaires	Surrounding greenness	Beneficial effects of green space were more pronounced in women
Sarkar, C. et al., 2018	94,879	U.K	Sex	Both	Questionnaires	Surrounding greenness	Beneficial effects of greenness were more pronounced in women/females who used the space 4 h a week or more
Raggi, A. et al., 2014	10,800	Poland, Finland and Spain	Gender	Both	Survey	Self-reported greenness	Gender differences are almost non-existent
Roe, J. et al., 2013	106	Scotland	Gender	Both	Questionnaire	Surrounding greenness	Beneficial effects of green space were more pronounced in women
Shu, S. and Ma, H., 2020	53	China	Gender	Girls/boys	Survey	Greenness quality	Beneficial effects of park soundscapes in boys and girls depending on the type of park noises
Annerstedt, M. et al., 2012	2,494	Sweden	Both	Both	Questionnaires	Surrounding greenness	Beneficial effects of nature were slightly more pronounced in women/females
Other mental health outcomes							
Helbich, M. et al., 2020	9,757	Netherlands	Both	Both	Observation	Surrounding greenness	Beneficial effects of greenery were more pronounced in women/females
Social health							
Dadvand, P. et al., 2018	10,856	Iran	Sex	Girls/boys	Survey	Self-reported greenness	Beneficial effects of green spaces stronger in young males
Ullah, H. et al., 2020	250,000	Shanghai	Gender	Females/males	Database	Greenness quality	Stronger association between green parks and use found in women
Toutakhane, A. M., 2018	400	Iran	Both	Women/men	Survey	Greenness quality	Strong gender differences between women's/females' and men's/males' behaviour in an urban park environment
Bahriny, F. and Bell, S., 2020	48	Iran	Gender	Women/men	Observation	Greenness quality	Perceived safety and other park qualities have a more pronounced influence in women's use of a park
Currie, M.J.Bos et al., 2016	13	Scotland	Gender	Women/men	Go-along interviews and observation	Greenness quality	Women and men obtain different well-being benefits from different greenspaces
Whitley, R. et al., 2005	6,200	England	Sex	Both	Survey	Greenness quality	Sex differences not found

[a] When the measure was obtained through a database or registration, we do not know how gender was obtained.
[b] The terminology we used reflected whether the papers studied sex or gender, without necessarily being the same as the terminology used by the papers to refer to their participants.

3.4.1. *Depression*

Six studies analysed the relationship between urban greenness and depression or depressive disorders (Raggi et al., 2014; Koohsari et al., 2018; Bos et al., 2016; Mullings et al., 2013; Engemann et al., 2019; Sarkar et al., 2018). Overall, the results show that urban greenness positively impacts depression and can attenuate depressive symptomatology, especially in women/females (Koohsari et al., 2018; Mullings et al., 2013; Sarkar et al., 2018).

Several studies stated the benefits of urban green environments in terms of quality and attributes concerning depression (Koohsari et al., 2018; Raggi et al., 2014; Mullings et al., 2013). For example, Koohsari et al. (2018) claimed that greener built environments could help with depression among older women, but such attributes in residential neighbourhoods do not have the same influence on older men's depression. Sarkar et al. (2018) also found out that green spaces in residential areas can install a positive psychological state attenuating major depressive disorders and that urban green spaces could uniquely help attenuate major depressive disorders in females more than in males. In contrast, and following the same direction of results, Raggi et al. (2014) pointed out how poorly built environments, those where home surroundings have been built and planned inadequately without much accessible or enjoyable green space, have a negative influence on people's usability of their neighbourhood environments.

Moving one step further in the understanding of the role played by greener urban environments, Bos et al. (2016), unlike previously cited studies, suggest that the benefits from urban green spaces relate to the actual use people make of them rather than its attributes and its proximity to people's place of residence. The study indicates that green spaces were associated with better mental health (e.g., improved levels of depression). However, these results are validated only for a specific age and gender group in a 3 km buffer. The largest effect sizes were observed in women aged between 18 and 24 and from above 65 years. Especially for men aged 45–54 higher green space were associated with more psychopathology. The authors suggest that findings can be explained by whether people have the opportunity to make use of urban green spaces.

In addition, one study zoomed in on a particular age group and pointed out how urban green spaces start to impact early in life. Engemann et al. (2019) pointed out how the presence of urban green spaces in childhood (from birth to 10 years old) is associated with a lower

chance of developing psychiatric disorders, including recurrent depressive disorder later in adulthood.

3.4.2. Stress

Five studies measured the correlation between urban greenness and psychological stress (Engemann et al., 2019; Roe et al., 2013; Annerstedt., 2012; Bos et al., 2016; Shu and Ma, 2020). The stress response to urban greenness was measured using psychological tests, statistics, and physiological measures, such as cortisol levels. Results highlighted disparities concerning psychological stress in women/females and men/-males. Although most of the studies emphasised that women benefited more from urban greenness, not all studies supported these results.

By examining cortisol concentration levels in participants, Roe et al. (2013) underlined crucial differences between women and men in stress patterns. The study showed how lower levels of green space, which Census Area Statistics (CAS) determined, in women resulted in higher stress levels. Similarly, Engemann et al. (2019) pointed to the positive correlation between improved stress-related disorders and greater green space density in girls. Additionally, the study by Annerstedt et al. (2012) found a reduced risk for poor mental health, such as stress among women/females related to green space qualities (e.g., space). Although the tendencies for men were similar, they were not as significant. Supporting Annerstedt et al. (2012) argument, Bos et al. (2016) also stated that green spaces improve stress levels more for women than men.

Going back to studies on children, Shu and Ma (2020) indicated that urban park soundscapes have a restorative impact on children's stress recovery; however, girls' and boys' stress levels react differently depending on which type of noise it is. For boys, ambient noise in urban parks showed a higher restorative impact compared to silence. Contrastingly, ambient noise for girls was significantly less pleasant than silence. In addition, only fountain sounds and silence were responsible for promoting stress recovery and emotional response for girls and not boys. The study emphasised that restorative soundscapes should be designed differently for boys and girls to help stress recovery.

3.4.3. Other mental health outcomes

The included studies also assessed other mental health outcomes such as suicide, schizophrenia, mood disorders, obsessive-compulsive disorder and borderline type disorder.

Concerning suicide, Helbich et al. (2020) showed that urban green spaces positively impacted people's mental health by highlighting how they help people cope with stress and pain caused by life events. Furthermore, the study showed how long-term exposure to urban green spaces close to people's residence can reduce the probability of suicide mortality later in life. The authors also state that for areas with low levels of urbanicity, only women/females presented a larger suicide risk reduction with increasing levels of NDVI. Thus, the study showed women/females benefited more from being in proximity to or living in areas with higher levels of green spaces since this characteristic of their environment seems to improve their resilience against suicide mortality for the future.

Engemann et al. (2019) study showcased how different mental disorders and their association with green spaces affect children differently. The study pointed out associations by gender between the measurements of green space in residential areas and the incidence rate ratio of psychiatric disorders. The authors found that the relationship between schizophrenia, mood disorders, and green spaces is more prevalent in boys. For girls, the relationship between obsessive-compulsive disorder and borderline type disorder is more prevalent than in males concerning green space density around each children's place of residence.

3.5. Social health

Last, six studies focused on social health (e.g., sense of safety and social contact) associated with urban greenness. All studies but one (Whitley et al., 2005) found differences between women/females and men/males.

3.5.1. Perception & use of urban greenness

Two studies have drawn upon essential mediators such as a sense of safety and belonging between the use of urban greenness and mental health outcomes (Bahriny and Bell, 2020; Currie et al., 2016). Although these two studies do not analyse specific mental health outcomes, they bring up relevant mediators that might influence the usage of urban greenness and, consequently, mental health.

Bahriny and Bell (2020) pointed out that security is an important mediator concerning park use. The study suggested that public parks suffering from a poor reputation might affect usage due to a higher perception of a crime risk, especially among women. The study done by Currie et al. (2016) also highlighted that people's perception of safety influences the frequency they take advantage of urban green spaces. The study showed how perceived safety influences the use of urban parks, which appears to be more crucial for women than men. Bahriny and Bell (2020) emphasised that the quality and maintenance of green spaces is also correlated with the level of use as it creates a sense of welcoming and safety. The authors pointed out that green space appearance and esthetics are especially more significant for women. The study showed that while men are well-catered for in these spaces (e.g., in terms of safety and accessibility), women are often left out in their own needs and preferences. The study concluded some parks because of their amenities, features, and design are seemingly more oriented to men's needs and preferences, thus being more used by men than women. In sum, these studies concludes that, since fear of crime has become an important topic of concern for residents in many cities in recent years, improving personal safety through well considered design, planning and management of urban parks in terms of security, comfort, and sense of being welcomed should be a focal point in creating these spaces so that everyone feels safe and welcome to use them.

Additionally, Currie et al. (2016) showed that the green spaces they analysed produced a sense of belonging attached to the local identity of some participants since some grew up near the green spaces the study took place in. The study showed that the green spaces brought some participants a sense of attachment and importance due to their history with the space, which was positively linked to improved well-being. Currie et al. (2016) also found that men felt more comfortable being in green spaces than being indoors compared to women. Men specifically stated in the study that they were feeling unhappy in indoor environments such as in their workplaces'. The study suggested that this is because green spaces made men feel less restricted and more at ease.

3.5.2. Social behaviour in urban greenness

Four studies examined the association between urban greenness exposure and social contact. All the studies showed a positive correlation between urban greenness and social behaviour. Social cohesion improved when people spent time in the study's different greenness (i.e., parks; urban environment; gardens).

Whitley et al. (2005) pointed out that shared public spaces can positively impact people's behaviour. The study showed that shared spaces preferentially with green areas can promote social support due to good relations with neighbours, which might contribute to better mood, improve mental health, and prevent its deterioration. The study pointed out the importance of social ties (e.g., positive social interactions with neighbours) in protecting mental health.

The studies also found social behaviour distinctions between women/females and men/males. Toutakhane (2018) asserted that urban parks are places for social interactions, but that gender influences the type of behaviour residents have in them and other green spaces. This study conducted in Iran emphasises the norms of no mixing of women and men in public places such as urban parks due to women's mandatory hijab. The results suggest that social-psychological factors could thus explain different social behaviour settings in urban green spaces. Thus, the author draws upon serious considerations associated

with urban green spaces of the psychological features of women and men in the context of religious beliefs. Similarly, Dadvand et al. (2018) found distinct social behaviour between young females and young males. The study, also developed in Iran, suggested a stronger association for boys between green spaces and improved social health in terms of social contacts. However, the study equally pointed out how this association is more pronounced in boys due to the social differences between girls and boys in Iran. However, Withal, Ullah et al. (2020), in a study done in Shanghai, China, suggested that the behaviour of residents in green parks is constantly evolving year after year, with women being more likely to visit the parks compared to men.

4. Discussion

This systematic review examined studies that investigate the relationship between mental health outcomes and urban greenness with a deeper look into gender and sex differences associated with them as well as how gender and sex are used in environmental health literature.

Our results showed how gender and sex have not been adequately analysed in association with mental health outcomes and urban greenness, frequent confusion between the two characteristics, and misuse of the terms when reporting results. In addition, the studies indicated that urban greenness seems to have particularly beneficial mental health outcomes in general and especially in women: Women tend to benefit from urban greenness despite not always having easy access, living nearby, not having greenness with features or amenities particularly appealing to their needs and preferences, or not feeling safe while using them.

4.1. Gender & sex

The conventional dichotomy between gender (the social dimension) and sex (the biological dimension) has been a problem in health research (Currie et al., 2016). However, in recent years, there has been an increase in the number of journals that include specific guidelines to encourage authors to pay attention to sex and gender-specific data (Bolte et al., 2019). These guidelines include the correct use of the terms gender and sex. This evolution points to the growing awareness of the misuse of these terms, such as in most of the studies included in this systematic review. Thus, a more gender-inclusive approach that focuses not only on the physical and biological aspects but also on social factors should be incorporated.

Many of the studies included used tables to show the data that was gathered which included information about the participants. However, by doing so, they misused the terminology by mixing gender with terms associated with the biological dimension, which brings up inaccuracy and confusion to the studies. Additionally, using the term sex in studies in which the results are associated with the social dimension and power structures present in society is problematic and points to ambiguous interpretations.

Concerning methodology, none of the articles reflected upon the possible gender bias there might exist when measuring the different mental health outcomes. Thus, they did not discuss or address critically whether these measurements might not be necessarily valid in all circumstances. Three studies used observation to collect data regarding gender. However, observation can lead researchers to misread people's gender identity. Gender identity is each person's experience of gender, their own sense of being a woman, man, neither or identifying themselves anywhere else in the gender spectrum (Ontario Human Rights Commission, 2022). Researchers can only assume their identity from their gender expression, which can also be misread and oversimplified. In addition, people's gender identity can be misread through the assumption that their sex will automatically match their gender. Therefore, the studies' neutral approach to gender roles risks being biased and potentially undermines the validity of the results. Besides observation, there were other qualitative data collection in the same line, such as surveys and questionnaires. This brings up the question regarding gender and sex and how they asked it. It could be that some participants did not identify with being gender binary. Thus, studies that were not gender-inclusive and unaware of gender non-conforming might have excluded participants simply by not adding gender non-binary options for participants to choose from. Studies in environmental health need to go beyond the traditional self-identification in which only two options exist for gender. Environmental health research studies might benefit from learning more from other disciplines such as feminist political ecology or feminist urbanism with more experience and maybe more knowledge concerning gender and sex differences in studying uses of urban spaces. This might benefit future urban greenness studies concerning mental health differences.

We also found that most studies do not justify or explain the terms chosen. Further, sex and gender were only identified and analysed in binary terms, as the biological and social dimensions separately and none of them examined the impact of the combination of gender and sex together. Bolte et al. (2019) use sex/gender as a new terminology to blur the lines between the binarity of the biological and social dimensions and state that sex and gender combined are important social health determinants to be considered comprehensively to avoid inaccurate research results. This understanding of sex and gender as a combination rather than as separate aspects, can also be known as embodiment of gender. Hunting et al. (2018) also agrees with the previous authors emphasising that sex and gender are essential determinants that enhance the understanding of health outcomes.

4.2. Mental health

Overall, despite the relatively low number of existing studies, the studies we included here showed a beneficial impact of urban greenness on improved mental health. However, there was no consistency in the results concerning differences between women's'and men's mental health in association with urban greenness. Several studies seem to point out how women/females, compared to men/males, have a greater potential to develop mental health disorders and might benefit more from urban greenness (Mullings et al., 2013; Roe et al., 2013; Sarkar et al., 2018).

Helbich et al. (2018) imply that exposure to greenery may contribute to a lower suicide risk, mainly for women. However, that might not always happen. In a study done in Jamaica, Mullings et al. (2013) highlighted that men/males lived in communities more likely to have more green spaces around them. The study also suggested that gender-based socio-cultural experiences such as fewer social opportunities and controlling behaviour towards women might be the reason men live in communities with higher levels of green spaces and why women do not get that opportunity. This puts them in disadvantaged circumstances, making them more vulnerable and at greater risk of poorer mental health. In addition, women in urban settings living in informal settlements were also more at risk of depression when considering environmental (e.g., disease outbreaks) and social hazards (e.g., limited social support). Digging deeper into this, the authors also highlighted social networks are mainly male-dominated in informal settlements. Informal Jamaican communities offer men protection, social mobility, and recognition, which could explain why men's mental health stayed protected in this context. This translates into women having little control over their own immediate environment and recurrently being victimised. Women tend to focus on their survival as well as their children when in an unsafe environment which might aggravate their risk of depression. Therefore, gender differences seem to intersect with other different societal roles and power structures, such as class and status, which seem to be those playing an important role explaining mental health inequality in urban greenness, rather than sex differences. The intersectionality of gender with other factors such as class and race has been deemed vital for the understanding of mental health differences by Rosenfield (2012).

4.3. Urban greenness exposure and perception

Study results also emphasised the importance urban greenness has on mental health. Sarkar et al. (2018) points to the benefits of well-designed green environments exposure positively influencing mental health. The study concluded that greenness in residential areas was constantly associated with lower levels of depression. Thus, residential greenness exposure has a protective effect on residents' mental health status. In addition, the study suggested that residents' closer residential proximity to higher levels of greenness might mean positive mental health benefits, with lower odds of depression. Similarly, the Ullah et al. (2020) study showed that park proximity influences the number of times a green spark is used. Easy access to urban greenness seems thus essential for improved mental health. However, assuming that urban greenness exposure is directly related to a participant's residence does not reflect the fact that many residents spend most of their time surrounded by the spaces around their workplace and school, and not only their home.

Urban greenness might be directly linked to better mental health (Sarkar et al., 2018). However, earlier research by Maheswaran and Lee (2010) showed that men use urban parks more than women. Literature suggests that if women are not in direct contact with urban greenness as men, they will not benefit from improved mental health outcomes in the same way, which will exacerbate gender inequality. Bahriny and Bell (2020) also suggested that some urban green spaces are more used by men than by women, with the hypothesis that their design and features do not allow women to feel safe. The results from the systematic search were unanimous in pointing to safety as an important mediator between mental health outcomes and urban greenness. Safety is a big concern for women, even from a young age, which influences their frequency and use of urban greenness compared to men. Research on safety perceptions associated with urban parks settings has drawn upon environmental cues such as low lighting and social cues such as other people's presence (Derose et al., 2017). Thus, gender relations shape safety perceptions which, in turn, might influence mental health outcomes differently for women and men. Although safety carries a big weight in urban greenness use, especially for women, safety issues were not considered in more than half of the studies we identified.

4.4. Social behaviour differences

Last, the literature included in the review suggests that gender differences could explain the results related to improved social contact in relation to greenness. Considering different concerns, preferences and even socio-cultural structures, women will perceive and behave differently in urban greenness than men (Toutakhane, 2018). Mullings et al. (2013) explained that informal social networks in Jamaica are mostly male-dominated, which results in women having poor control over their own surroundings and frequently being victimised. This suggests that women do not always have the same opportunity to create and enhance social connections in these spaces as men do.

These distinctions in behaviour and concerns between women/females and men/males start at a young age. Girls tend to use urban greenness less than boys (Boxberger and Reimers, 2019). Dadvand et al. (2018) found stronger associations of social behaviour for young males compared with young females. According to the authors, Iranian young males might have more freedom to socialise in an urban greenness environment, while Iranian young females do not have such liberty and are more dependent on their families. Another possible explanation is due to parental perceptions of safety for their children, especially with young females. Boxberger and Reimers (2019) stated that parents are more likely to let boys play alone outdoors than girls. Hence, parents tend to be more protective of their daughters than their sons due to fear of violence. Studies included suggest this translates to less time spent in greenness for girls compared to boys.

4.5. Future research

The systematic review results show how gender differences impact mental health outcomes as opposed to sex differences in an urban green environment. However, none of the studies went deep into these differences as potential explanations for their results.

Equally, our results suggest the importance of considering gender intersectionally with other social and power structures in future studies. These ignored structures might exacerbate the gender differences regarding mental health benefits obtained from urban greenness. The literature suggests that societal power structures and gender differences together are why urban greenness might unequally distribute mental health benefits towards men while hindering those that women could harness. For instance, three studies were carried out in Iran (Dadvand et al., 2018; Toutakhane, 2018; Bahriny and Bell, 2020), where women's roles in society and free use of greenness will be more restrictive than the ones developed in northern Europe countries. Toutakhane (2018) indicated how the official religion in Iran, Shia Islam, is a crucial determinant of the differences between women and men concerning urban greenness use. Hence, considering religion and other socio-cultural factors, women and men cannot mix, making it more difficult for women to obtain the same mental health benefits as men in an urban greenness setting. This highlights gender differences present in Iran's society, which result in gender inequality related to mental health.

Additionally, the studies included sex and gender terms inadequately used, which is problematic because it might lead to inaccurate results. Further studies should be more conscious of the differences between sex and gender and their terminology. Furthermore, future studies should consider gender as a spectrum and not reduce it only to the binary terms of women and men for better inclusivity. This will enable more complete and accurate results to avoid inequalities and exclusion of social groups in environmental health evidence. Therefore, future studies related to urban greenness must address, using appropriate and inclusive terminology, both the biological and social dimensions that shape these differences in mental health outcomes.

4.6. Strengths & limitations

Despite our comprehensive search, a limitation of the review relates to the possibility that we might have missed additional studies that pointed out both sex and gender differences related to mental health outcomes in an urban greenness scenario. This is due is to the many ways the literature can refer to interaction, stratification or effect modification by sex and gender. Our search included these terms as keywords for sex and/or gender differences. However, we used a snowball methodology to ensure that we still had a representative sample of the literature on the topic Another limitation of this review relates to the exclusion of all non-English papers. This may have limited the papers' location, with mainly countries from Europe and Asia. As we have addressed in this paper, gender is socially constructed. Thus, as each country and region has constructed its own set of social and cultural norms, gender is likely to be expressed and embodied differently according to those norms, urging for a further study of other locations in the rest of the world.

The main strengths of this systematic review include a specific criteria-based approach to the selection of the articles. Since there is a gap in the literature concerning both sex and gender differences in mental health associated with urban greenness, our defined eligibility criteria for inclusion provided relevant evidence to achieve the research aims. Thus, the specific criteria enabled the review to identify the need to incorporate gender issues into environmental health research. In this manner, we used the PRISMA reporting guidelines, which we believe is another strength of the systematic review. It enabled us to improve the reporting of our results. Equally, having another reviewer double-checked the work, especially in the search process, enhanced the review quality and helped uncover any blind areas of the other reviewer. Additionally, another strength relates to the focus on the most common

mental health disorders and our spotlight on social health outcomes for which clear health disparities exist.

5. Conclusion

This systematic review highlighted various studies that do not adequately assign sex and gender terms in association to mental health outcomes in an urban greenness environment. In addition, the studies we identified point to women benefiting more from urban greenness but being less likely to use urban greenness than men. This could be because of safety concerns and due to gender norms and societal roles. In addition, it could also be explained by the fact that the quality and characteristics of these spaces are not designed and planned for women the same way they are for men. Therefore, urban greenness may unequally distribute mental health benefits in women compared to men. Future studies need to analyse in depth societal gender differences associated with mental health and urban greenness and use the right terminology for it to properly assign characteristics and uses of greenness with mental health outcomes and their pathways.

From a policy and planning perspective, in order to ensure greater gendered equity and justice in greenness planning, we call on park planners and designers to carefully plan new greenness with the active voice of female residents especially children and include design, recreational, natural, and safety features that particularly respond to their individual and socio-cultural needs and preferences.

Urban greenness can improve mental health outcomes among all residents, but for women to benefit from these spaces, policy interventions are needed to address programming and design issues that can facilitate the use of urban greenness among women. Inclusive program and planning of urban greenness in which residents of both sexes and all genders can feel safe and represented in these spaces might help decrease mental health disparities between women and men associated to urban greenness. For instance, addressing environmental and social cues in parks through maintenance and design could help mitigate some of the most pressing safety issues to women. In addition, designers and planners could add pathways easy for strollers and playgrounds for kids so that both children and parents can benefit from urban greenness at the same time. Otherwise, cities risk excluding residents, in particular women and girls, and their health needs and outcomes from green and healthier cities.

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Appendix A. Supplementary data

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