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REVIEW ARTICLE

Did the COVID-19 pandemic influence access to green spaces? Results of a literature review during the first year of pandemic

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Abstract
Context The restrictions imposed in response to the COVID-19 pandemic disrupted the relationship between humans and their environment. The studies analyzed focus mainly on urban spaces during the first year of the COVID-19 pandemic.
Objectives The aim of the present study was to assess the changes that the COVID-19 pandemic has caused in the relation between humans and nature, including the view, use, and perception of green spaces.
Methods This review was performed by keyword searches in the main bibliographic repositories. We included all studies that examined the relationship between green spaces and nature during the COVID-19 pandemic. The search was restricted to studies published in English from the end of 2019 until the end of March 2021. Following the inclusion criteria, a total of 31 articles were analyzed.
Results The COVID-19 pandemic has modified the relationship between population and green spaces. In countries with fewer restrictions, some travel was permitted, and green spaces could be visited. Countries with more severe restrictions, such as Spain and Italy, registered a significant reduction in the use of green spaces, especially during home confinement. The issues addressed by most studies analyzed include variations in access and use to green space and its economic inequalities, the influence of views of green space on well-being and the associations between COVID-19 rates and availability of green spaces from the beginning of the pandemic until March 2021.
Conclusion The different government responses to COVID-19 have influenced the access to and use of green spaces, showing an increase in the exposure and appreciation of green spaces. Green spaces have increased the resilience of both cities and their residents, especially during the pandemic lockdown.

Keywords COVID-19 · Pandemic · Green spaces · Natural environment

Introduction

The SARS-CoV-2 virus is transmitted by respiratory droplets in the air and on other surfaces (Chen et al. 2020), therefore most governments in different countries implemented measures to prevent the spread of the virus (Honey-Rosés et al. 2020), including lockdown (Farsalinos et al. 2021) and travel restrictions (Sabat et al. 2020). Responses to the pandemic varied

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widely around the world, including countries such as Israel, Lithuania, Croatia (Ugolini et al. 2020) or Norway (Venter et al. 2020) where authorities decided to maintain daily routines in everyday activities, to other countries—such as China, Italy, or Spain—where more restrictive measures were implemented, including home confinement (Guo et al. 2021).

Initial preventive measures adopted by governments included closing leisure areas such as bars, restaurants, cinemas, shopping centers or festivals (Saez et al. 2020), encouraging work from home and e-learning, reducing social interaction (Slater et al. 2020). In the face of increasing cases and hospital pressure, restrictions—aimed at limiting person-to-person contact—such as non-essential activities (Ibn-Mohammed et al. 2021) or travel bans (Chinazzi et al. 2020) were imposed. In addition, in response to the government's recommendations, many residents decided not to travel and stay at home (Yang et al. 2021). In countries such as Spain and Italy, these measures affected outdoor public spaces with protected areas, urban parks or gardens (Cahyadi and Newsome 2021; Souza et al. 2021), and even beaches (Guo et al. 2021) being preemptively closed. However, in other countries such as Canada or Denmark, without less severe restrictions, the use of green spaces during the pandemic increased considerably (Geng et al. 2020). In England and France, although severe containment measures were applied during peaks of SARS-CoV-2 infections, access to and use of green spaces was permitted (Day 2020). Regardless of the level of restriction, some studies have highlighted social inequalities in access to nature during the pandemic, due to disparities in the availability of home gardens (Spencer et al. 2020).

Green spaces play an important role in improving health and well-being (Hartig et al. 2014; Kaplan 1995). Numerous studies have analyzed the relationship between mental health, well-being and nature, in most cases finding positive associations (Sandifer et al. 2015; van den Berg et al. 2015; White et al. 2021). With the outbreak of SARS-CoV-2, studies exploring the associations between environmental factors and humans have become more widespread, the role of green spaces in different scientific disciplines has been investigated (Taylor and Hochuli 2017). During the pandemic, people experienced higher levels of anxiety or depression (Qiu et al. 2020a; Wang et al. 2020), loneliness (Bu et al. 2020) and irritability (Panchal et al. 2023) that resulted in a decrease in well-being (Spano et al. 2021). Other symptoms such as sleep problems also increased during this pandemic period (Idrissi et al. 2020). Measures such as home confinement or perimeter confinement influenced the nature-human relationship, especially among the most disadvantaged population, as they have more difficulties in accessing green spaces (Braubach et al. 2017).

Green space features also influenced perception during COVID-19, for example, Ye and Qiu (2021) applied landscape ecology to investigate the role of landscape features in the virus spread and transmission, emphasizing the importance of green spaces in improving quality of life. Although different studies have reported a positive association between urban green spaces and improved physical and mental well-being (Jabbar et al. 2022), there is insufficient evidence on the role played by green spaces during the COVID-19 pandemic (Xie et al. 2020). The present literature review aims to assess the changes that the COVID-19 pandemic has brought about in the interactions between humans and green spaces and nature, including access, use, view, and perception. Therefore, the following research questions were established:

1. Have green spaces mitigated the negative effects on mental health and well-being during the first year of the COVID-19 pandemic?
2. Under what conditions did the population use green spaces and what were the characteristics of these spaces?
3. Could view from home be a replacement for contact with nature in regions where access to green spaces was not possible?

Methodology

This research analyzed studies that explored the influence of COVID-19 on the access and use of green space, including how it affected mental health and alternative ways of being in contact with nature during the first year of the pandemic. For this purpose, a search was conducted in the bibliographic databases Scopus, Web of Science and Publish of Perish, using combinations of the following keywords: "COVID-19", "coronavirus", "SARS-Cov-2", "pandemic",

"lockdown", "green space", "blue space", "nature", "plants", "environment", and "perception".

Inclusion criteria

We included scientific articles on interactions between people and green spaces and nature during the COVID-19 pandemic, written in English and published between the beginning of 2019 and March 2021. Keywords used in the searches—mentioned above—had to appear either in the title, in the abstract or in the keywords of the articles considered. Given the global scope of the pandemic, no region or country was excluded.

The search strategy was based on the combination between two and four keywords connected with Boolean operators per search with a result of 317 publications, of which 230 were excluded because they did not meet the inclusion criteria. After eliminating 31 articles that were repeated, 56 articles were obtained, which were read and assessed. Nine articles were eliminated for not including relevant data for the review and 22 articles were excluded for being descriptive in nature. In addition, six studies that were cited in the bibliography sections of the selected articles were identified and added to the review. Although these six studies had not been identified in the keyword search engines, we decided to include them as they provided evidence for the purpose of this review. Two researchers (M.G.-C. and A.G.-M.) independently read, summarized, and analyzed in detail the final 31 selected articles before including them in the literature review (Fig. 1).

The evidence generated has been systematized in summary tables—divided by topic—that include the following information: authors, year, geographic location (country, region, or city) where the study was conducted, spatial scale, study aims, socioeconomic level, type of variables, results and pandemic situation, including the degree of restrictions. Depending on the objective and the methodology used, the articles analyzed were classified into the following four themes: (i) Mobile data and mobility to green spaces. They analyze access to green spaces from a mobility perspective, using mainly mobile data collected by Google Mobility; (ii) Changes in the use and perception of green spaces. This topic included articles aimed to understand the influence of the pandemic on the use and perception of green spaces, using different methodologies (mainly online surveys and spatial analysis); (iii) COVID-19 risk and built environment. Studies analyzing the relationship between green spaces and the risk of SARS-CoV-2 infection were included; (iv) Socio-economic factors in access to green spaces during the pandemic. These are articles assessing how socioeconomic factors influenced access to and use of green spaces during the COVID-19 pandemic. Description of the studies are available in Supplementary Table 1.

Of the 31 studies selected, nine have compared access to green spaces with a pre-pandemic baseline period (Day 2020; Derks et al. 2020; Heo et al. 2020 Geng et al. 2020; Qiu et al. , 2020b; Rice and Pan

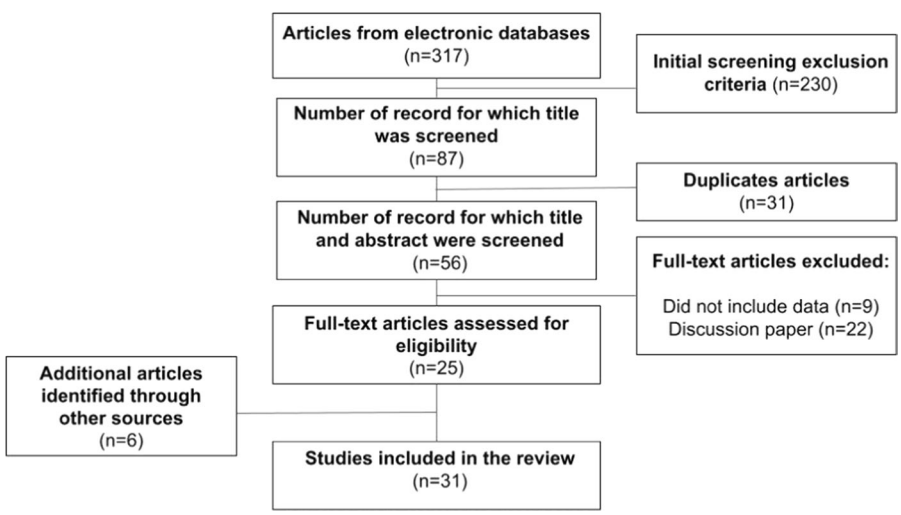

Fig. 1 Literature review flowchart. The total number of studies identified, the reasons for exclusion and the studies included are shown

2021; Rousseau and Deschacht 2020; Venter et al. 2020; You and Pan 2020).

Green spaces are open urban areas dominated by vegetation, such as parks, gardens, forests, or lots (Taylor and Hochuli 2017). Therefore, the terms green spaces and nature are used in this paper with the same meaning. However, it should be noted that the selected studies use different terminology, the most commonly used terms being: urban green spaces (n = 4), green spaces (n = 4), park (n = 3), nature (n = 3), urban park (n = 2), public green space (n = 2), green areas (n = 2), state parks (n = 2), outdoor recreation areas (n = 2), natural areas (n = 1), historic gardens (n = 1), green streets (n = 1), forest (n = 1), greenery (n = 1), urban vegetation (n = 1), and plants (n = 1).

Most studies conducted data collection between January 2020 and May 2020 (n = 8) or between March 2020 and June 2020 (n = 5). These were months in which the pandemic spread to practically all countries in the world. Since they were conducted during the first year of COVID-19, just after the World Health Organization (WHO) declared the outbreak of the novel coronavirus (COVID-19) a global pandemic, these studies should be considered pioneering in the analysis of interactions between humans and green spaces/nature at a time of a global health crisis.

Results

The present review comprises a total of 31 articles that were analyzed. As for the spatial scope of the papers included in the review, Table 1 shows the territories covered by each of the studies. Most of the studies were located in the USA and Hong Kong, as well as studies that examined several countries. Among the studies that did not specify the area of implementation was a review of the scientific literature (Spencer et al. 2020).

The reviewed studies highlight the diversity of methods used to assess the effects of the pandemic on green spaces. Five studies used mobile data provided by Google Mobility (Day 2020; Geng et al. 2020; Heo et al. 2020; Rice and Pan 2021; Venter et al. 2020). Others studies used online surveys (Büssing et al. 2020; Dzhambov et al. 2020; Hodor et al. 2021; Landry et al. 2021; Legeby and Koch 2020; Morse et al. 2020; Paköz et al. 2021; Pérez-Urrestarazu et al. 2020; Pouso et al. 2020; Rice et al. 2020; Uchiyama and Kohsaka 2020; Ugolini et al. 2020; Xie et al. 2020) and face-to-face surveys (Derks et al. 2020; Grima et al. 2020). Six studies used validated scales to assess population health (Büssing et al. 2020; Dzhambov et al. 2020; Pouso et al. 2020; Qiu et al. 2020b; Xie et al. 2020; Zordan and Tsou 2020). Other studies used geospatial information to analyze the association between land uses and the environment of green spaces (Nguyen et al. 2020; Rice et al. 2020), the accessibility in distance and access in time (Shoari et al. 2020) or the estimation of square metres of public green space per inhabitant (Cascetta et al. 2021). Vegetation indices to measure the area of green space and calculate greenness (Venter et al. 2020; You and Pan 2020) are also notable. Three papers

Table 1 Location of studies

Scope of study	References
Set of countries from all continents	Geng et al. (2020)
Several countries in Europe, America, and Oceania	Pouso et al. (2020); Pérez-Urrestarazu et al. (2020)
Several countries in Europe	Ugolini et al. (2020); Rousseau and Deschacht (2020); Hodor et al. (2021)
USA	Grima et al. (2020); Heo et al. (2020); Landry et al. (2021); Morse et al. (2020); Nguyen et al. (2020); Rice et al. (2020); Rice and Pan (2021); You and Pan (2020)
Hong Kong	Huang et al. (2020); Kan et al. (2021); Zordan and Tsou (2020)
England	Day (2020); Shoari et al. (2020)
China	Xie et al. (2020); You et al. (2020)
A single country or region	Büssing et al. (2020); Cascetta et al. (2021); Derks et al. (2020); Dzhambov et al. (2020); Qiu et al. (2020b); Legeby and Koch (2020); Paköz et al. (2021); Uchiyama and Kohsaka (2020); Venter et al. (2020)

examined the relationship between the built environment and the risk of SARS-CoV-2 (Huang et al. 2020; Kan et al. 2021; You et al. 2020). Two articles analized the degree of interest in the environment during the COVID-19 pandemic through web searches and the availability of nature-related data on the internet (Rousseau and Deschacht 2020; Venter et al. 2020). Other studies were based on reviews of the scientific literature associating access to green space to income (Spencer et al. 2020). For further information on variables employed in studies included in this literature review, please refer to Supplementary Table 1. Articles were classified by topic according to the objective and methodology used, as detailed in the methods section. The articles included in this review focus on different geographical areas (regional, national, sub-national or local), focusing mainly on urban settings. However, it should be noted that the studies indicate that most of the mixed category responses of urban and rural areas contain responses from respondents from urban localities. Therefore, the studies were mainly focused on urban areas, although rural areas have also been considered in this review. The number of studies belonging to urban, rural or mixed scales is shown as follow in Table 2.

The rapid response of researchers to the COVID-19 phenomenon is remarkable, as most of the studies were initiated during the months of March and April 2020, just after the World Health Organization (WHO) had declared the novel coronavirus (COVID-19) outbreak a global pandemic on 11 March (Cascella et al. 2020).

The main results obtained are presented below according to the subject matter covered. First, we explore the results related to changes in access to green spaces. Afterwards, we compiled the different uses of green spaces during the first year of the pandemic, perceptions, and views of green spaces, and finally, the relationship between the presence of green spaces and the risk of SARS-CoV-2 infection.

Table 2 Areas of analysis

AREA	N
Urban	15
Urban and rural	13
Rural	2
Without typology	1

Access to green spaces

The pandemic has prevented or modified access patterns to green spaces, mainly due to containment measures or fear of transmission (Arora et al. 2020). Studies analyzed show a great variability in access to green spaces and protected areas depending on the country. The studies analyzed, as shown in Supplementary Table 1, have different methods, sample sizes and study time, given the global scope of the phenomenon. Although we are unable to establish direct comparisons between these studies, in general, there are several countries such as England, USA, Germany, or Norway where different degrees of increase in access to green spaces were reported. In Oslo, a quick 19-day survey found that outdoor activities increased by 291% during the lockdown period including visits to green spaces, protected areas and walks through areas with vegetation (Venter et al. 2020). On the other hand, during the second shutdown period in England, visits to green spaces increased by 37% compared to the baseline period (January–February 2020) (Day 2020), 20.2% compared to the pre-COVID-19 period in the western region of the USA (Grima et al. 2020; Rice and Pan 2021) or by 140% in the Kottenforst forest in Bonn (Germany) (Derks et al. 2020). In a study conducted in Burlington (USA), 70.2% of respondents reported "increased" and "significantly increased" access to urban and peri-urban natural areas during the pandemic compared to the baseline period (Grima et al. 2020). Similarly, the study by Geng et al. (2020), including 48 countries, reported an increase in visits to green spaces compared to pre-pandemic dates through mobile data in 48 countries, correlated primarily by the rate of government stringency and workplace closure. However, Landry et al. (2021) conducted a study in, the USA on a random sample of 1,020 people, reported a 26% decrease in visits to green spaces, mostly in elderly population. These differences could be due to the fact that the data were obtained using a revealed preference survey versus the data of Geng et al. (2020) which were obtained with mobile phone tracking. Information collected from surveys may not be comparable to data obtained by objective quantitative methods such as mobility studies with telephone antenna positioning

because surveys cannot be verified as they are anonymous and personal information. Therefore, comparison of studies with different methodologies should be carried out with caution. Increase in access to green spaces was reported in countries with less severe restrictions, such as Norway (Venter et al. 2020) or England (Day 2020). In countries with more severe restrictions, such as Spain or Italy, users were unable to access green spaces as mobility was restricted due to home confinement. Specifically, 64% of the respondents who used to visit green spaces before the pandemic in both Italy (n = 366) and Spain (n = 571) did not visit urban green spaces during the COVID-19 lockdown (Ugolini et al. 2020). In other locations, like Turkey, green spaces were the public space that lost the largest number of users during the pandemic, with a 72.7% reduction in visitors, compared to other types of spaces such as open areas or public buildings (Paköz et al. 2021).

Regarding the effects of closure or decreased visitor numbers, only one study assessed the implications for the maintenance and conservation status of flora in green spaces (Hodor et al. 2021). Park closures negatively affected the conservation status of 31 European historic gardens during the period June to August 2020, as maintenance care was reduced. However, environmental quality has improved, particularly in terms of increased vegetation and improved biodiversity (Hodor et al. 2021). In addition, there were also changes in the transport mode by which users travelled to these green spaces, with an increase in walking visits (Day 2020; Ugolini et al. 2020). Similarly, Xie et al. (2020) found that more than half of the respondents living in the city of Chengdu (China) visited parks near their homes. In lower-density areas with close access to parks, people maintained their mobility patterns, avoiding travel to densely populated areas where the risk of infection could be higher (Heo et al. 2020; Venter et al. 2020). According to a recent study in the UK, a higher urban density was associated with greater accessibility to green spaces, however, these spaces were less attractive to the population as they did not allow the two-metre distance recommended by the authorities (Shoari et al. 2020). In a longitudinal study conducted in the USA, data on access to green spaces were collected during two periods: from March 11 to April 9 and from April 9 to April 30, 2020 and it was concluded that the US population reduced the distances and frequencies of travel for outdoor activities in the first period and increased it in the second period (Rice et al. 2020).

Furthermore, another study, based on a literature review associating income and access to green space for outdoor physical exercise, suggests that low-income level was the factor most related to lower access to green spaces, rather than the effect of COVID-19 on green space use (Spencer et al. 2020). Conversely, high income level was related to higher access, as for example in the case of Japan (Uchiyama and Kohsaka 2020).

Uses of green spaces

Restrictions on gatherings and working from home boosted the use of green spaces (Day 2020; Geng et al. 2020). In pandemic times, with the closure of indoor recreational spaces, leisure activities were moved to open spaces and green spaces (Paköz et al. 2021). Evidence of this can be verified by comparing the pre and post COVID use of green spaces, for example in Hong Kong where before the pandemic only 19% of respondents chose green spaces for leisure time, compared to 65% in the post-COVID era (between 6 and 19 of April 2020) (Zordan and Tsou 2020). In a study conducted in six European countries between April and May 2020, the main reasons for visiting green spaces were sports activities, relaxation, and, to a lesser extent, accompanying children and walking the dog (Ugolini et al. 2020). Based on the results obtained in Oslo, Venter et al. (2020) report that, in general, green spaces replaced enclosed spaces, such as gymnasiums, which were closed due to pandemic restrictions, while outdoor sporting activities were allowed. In fact, the evidence suggests that green spaces are places that promoted physical exercise, providing an improvement in well-being in times of crisis (Spencer et al. 2020). Regarding the benefits by the use of green spaces, a significant proportion of participants in the study conducted in Germany respondents stated that the visit to the forest were associated with sounds, smells or memories that brought them positive emotional and spiritual feelings (Derks et al. 2020). It also highlighted the use of natural areas in the pandemic period for walking above all other activities, as demonstrated by Morse et al. (2020) in their study where it was reported that women were significantly more involved in the use of green spaces. In addition, it was also reported that

people who had lost their jobs were more likely to be active in nature. As the streets did not offer adequate conditions for walking—while maintaining social distancing norms—parks and protected areas were used. Grima et al. (2020) concluded in their work that protected areas were used in the pandemic to maintain social relationships, as a safer space than other environments. In a survey of the new routines imposed by COVID-19 in Stockholm, 2/3 of the places visited by the surveyed population were green spaces (Legeby and Koch 2020). However, it is important to note that the pandemic has had an impact on the use of natural spaces outside the urban environment. For example, in the USA, 56% of recreational trips to National or State Park were cancelled highlighting differences between urban green spaces and state parks, which are located further away from cities (Landry et al. 2021).

Fewer studies assessed the duration of the visit, although it was found that the longer the duration of each visit, the greater the impact on general, physical, and mental health (Rice et al. 2020; Xie et al. 2020). There were no significant variations in visits between weekdays and weekends, although there were changes in access day times (Derks et al. 2020). During the pandemic, in the case of the city of Bonn (Germany), there were peaks before and after office hours (Derks et al. 2020), which suggests that face-to-face work promoted access to green spaces to a greater extent. In Oslo (Norway), flexible working hours due to working from home resulted in even access to green spaces throughout the day during the analysis period 12–31 March 2020 (Venter et al. 2020).

The reduction in visits to green spaces has been mainly due to home confinement and mobility restrictions in the countries studied by Geng et al. (2020), which include 48 countries from around the world. However, other studies did not associate changes in visit frequency to the COVID-19 pandemic, but rather seasonality and changes in temperatures, according to a study in the western region of the United States (Rice and Pan 2021) or even reported a decrease in the number of visits as a consequence of a higher incidence of COVID-19 (Paköz et al. 2021). In the study conducted in Nagoya (Japan), during the summer of 2020, households with children were also found to use green spaces more often than those without, and young people visited them more than older people (Uchiyama and Kohsaka 2020). In addition, a higher number of new visitors were found, and it was confirmed that regular visitors lived close to the forest in the survey conducted in the Kottenfrost forest (Germany) with 292 participants (Derks et al. 2020).

Perception and views

In addition to access and use of green spaces, which could be categorized as direct relationships, indirect relationships, linked to perception, senses, and psychological effects, have also been assessed. Regarding indirect interaction with green spaces, the possibility of perceiving and seeing natural elements that make up green spaces, both in face-to-face visits and in views through windows, stands out (Elsadek et al. 2020). In particular, the importance of views lies in the theory of stress reduction (Ulrich 1981), which has fostered studies verifying that people who are exposed to natural environments experience positive feelings, compared to those who are exposed to grey spaces, i.e., places with a predominance of buildings (Lee et al. 2009). Velarde et al. (2007) conducted a meta-analysis on visual exposure to natural landscapes, showing that visual contact with natural spaces improves general well-being, reduces stress, increases attention span and helps recovery from illness.

Regarding nature perception during the COVID-19 pandemic, a study conducted in 20 European countries found a positive association between the pandemic and interest in nature (Rousseau and Deschacht 2020) and in disease-affected populations (Büssing et al. 2020). The study by M. Qiu et al. (2020b) evaluated the effects of sounds in national parks in Australia, which were more diverse and positive for the restoration of visitors' mental health during the pandemic period, mainly due to fewer visitors to the parks. According to a study conducted in Plovdiv (Bulgaria) using an online survey, looking out of the window at views of blue spaces or having plants at home can produce the feeling of being outdoors (Dzhambov et al. 2020). In the study by Ugolini et al. (2020), the most beneficial views from respondents' homes were to private gardens and tree-lined streets in the countries of Croatia, Israel, Italy, Lithuania, and Spain.

Landry et al. (2021) found that the pandemic situation reflected in a poorer quality of the experience of using outdoor spaces, either because these spaces

were more neglected or because they felt most likely to be infected in these spaces. According to the results of the perception survey in this study, the perception of being infected by COVID-19 in a sample of 1,020 U.S. respondents increased by 24% when visiting outdoor spaces such as green spaces, but 78% of respondents rated the restrictions applied in outdoor recreational spaces as reasonable.

Green spaces have the particularity that they allow exposure to fresh air, making it possible to view the sky. According to Huang et al. (2020), being able to look at the sky is associated with a reduction in the perceived risk of infection. This association has been shown to be effective when the sky can be viewed from the home in Hong Kong, where housing conditions often prevent viewing the sky from home windows. A study in Bulgaria among 323 students found that having vegetation visible from home or in the neighborhood environment was associated with a reduction in symptoms of depression and anxiety levels, which increased due to the pandemic situation (Dzhambov et al. 2020). Results supporting this hypothesis were also obtained in Spain, where those who had accessible outdoor spaces and blue elements such as lakes or beaches nearby had positive feelings or emotions, compared to those who did not have these amenities (Pouso et al. 2020). In this way, the natural environment is shown to have an impact on resilience during the pandemic, as well as protective implications against psychological disorders. Despite this, studies such as Pérez-Urrestarazu et al. (2020) report that although being in contact with plants in the home has a positive association with wellbeing, 60.3% of the 4,205 respondents from Brazil, Greece, Spain, and Italy will not increase the number of plants in the home when the lockdown period ends.

Risk of infection in green spaces

The main characteristic of green areas, which are open spaces in the open air, is that they allow the removal of stale air. Accessing greenery has been shown to have less risk than other activities like going to stores and offices (Johnson et al. 2021). Studies have assessed extent to which the availability of green space can influence the spread of the virus and whether it spreads faster or slower accordingly. The concentration of green spaces tends to attract a larger number of users, creating a hotspot. During the study period of the paper by Huang et al. (2020) and Nguyen et al. (2020) prior to April 2020, it was suggested that the concentration of visitors led to a higher number of confirmed cases (Kan et al. 2021; You et al. 2020). Most of these studies have been conducted in Asian cities, where there is a high concentration and density of population. Other studies such as that conducted in 48 countries around the world, including North and South America, Europe, Australia, South Africa, Egypt and India, suggest that the number of infections was not related to the number of visitors to green spaces, precisely because the risk of infection outdoors is much lower and also because parks do not tend to invade interpersonal distance (Geng et al. 2020).

One of the main issues debated during the pandemic has been the potencial decrease in the likelihood of infection in outdoor spaces (Johnson et al. 2021). Cascetta et al. (2021), showed that public green space led to a decrease in the rate of hospitalisation. In New York City, a study conducted during the first wave of the epidemic revealed growing concerns about the lack of social distancing and overcrowding in urban green spaces, which made these areas less popular than they were prior to the outbreak (Lopez et al. 2021). As a result, there may be an increased likelihood of becoming ill during a pandemic. Furthermore, although accessibility has tended to be good in most parks, results from England and Wales (Shoari et al. 2020) indicate that there is a risk of overuse of the park by the population, since if all users accessed their closest park the volume of users would be sufficiently high that the social distancing rule could not be maintained. You and Pan (2020) showed that urban vegetation can slow down and reduce the spread of COVID-19. According to their estimations, 1% of urban vegetation would lead to a 2.6% decrease in cumulative COVID-19 cases in 989 counties of the USA between March 14 and May 24, 2020. However, in Kan et al. (2021) study, conducted in Hong Kong, the areas with the highest risk of more severe disease or outcomes from COVID-19 infection were also those with more green spaces. These disparities are due, beyond the different scales and study methodologies, to the fact that in Asian countries the population density is higher than in the rest of the world, and specifically the places with the highest concentration of population—and therefore of confirmed cases—have the highest concentration

of urban green spaces.. Another study conducted in Hong Kong by Huang et al. (2020), between January and April 2020, with data from confirmed cases from the Hong Kong Health Department between January and April 2020, analyzed the risk of COVID-19 as a function of incidence rate (confirmed cases per 1000 inhabitants) and site density (enclosures or buildings visited by confirmed cases). They found a positive association between green spaces density and COVID-19 incidence rate and furthermore a negative association was found between population density, incidence rate and buildings visited by confirmed case. Although this result seems contradictory to the evidence that higher population density positively affects the rate of infection or risk of infection, the authors suggest that, in Hong Kong, highly populated cities are more compliant with pandemic containment measures than suburban areas with lower perceived risk.

Discussion

This review of the scientific literature has provided evidence of the impact of the COVID-19 pandemic on visits, uses, and perception of green spaces. A total of 31 articles published between the end of 2019 (emergence of SARS-CoV-2) and March 2021 were included in this review.

Based on the studies analyzed, it is possible to answer the initial questions posed in the current research. The first research question aimed to answer about the benefits that green spaces have provided to the population. Although it should be taken into account that the studies have different scales, methods, time periods and samples, it can be underlined that more than 50% of the studies supported the benefits of green spaces during the pandemic, although more than one third of the studies did not specifically address this question. These studies have corroborated the benefits of green spaces on mental health and well-being, increased social interactions, improvement of the conservation status of green spaces due to the reduction of visitors, and increased appreciation of nature.

The second question sought to explore the conditions of access and use of green space, as well as the characteristics of the spaces. Most items reported an increase in green space users during the pandemic, versus a small portion of these reporting a decrease in green space use during the pandemic. Other studies (17%) considered that it depended on factors such as country, date of data collection, and sociodemographic characteristics, while 22% were undecided. The COVID-19 pandemic increased the use of green spaces after periods of maximum risk of infection. The impossibility of accessing other leisure spaces has boosted outdoor activities in green spaces, especially walks and physical exercise. Similarly, the use of green spaces by non-regular users has increased, extending the benefits of nature exposure to people who are not used to visiting those spaces. Although new users were attracted, sociodemographic factors such as income, age or gender are predictors of green space use. In fact, having a higher income, having children and/or a dog, and being young or elderly were associated with greater use of green space, as was already the case in studies before the pandemic. Secondly, we observed that in geographic areas with lower population density and urban sprawl residents were able to maintain a closer relationship with their natural environment.

The third question focuses on the replacement of access to green spaces by views from the home when restrictions prevented going outdoors. Although a minority of studies have focused on this issue, the results suggest that having plants in the home and viewing the outdoors report positive effects on the mental health and well-being.

The pandemic has exposed the importance of adequate green spaces characteristics and as most spaces are not equipped to cope with the needs of social distancing and hygiene imposed by the pandemic situation (Freeman and Eykelbosh 2020). The general recommendation to maintain 1.5 m to 2.0 m of interpersonal distance cannot be met if it is a small green space in a densely populated area. However, green spaces are often unattended or understaffed, so disinfection of common areas is often not carried out. The most successful measures for the use and enjoyment of green spaces are measures such as park schedules dedicated to different age groups or staggered access according to neighborhoods, as well as capacity control through mobile applications. However, such measures have only been included in the study by Shoari et al. (2020) which raises the question of why, during the first year of the pandemic, the studies did not consider this possibility of park management. In

times of crisis, such as those experienced by COVID-19, having a change system that allows all citizens to access public spaces, such as outdoor spaces, green areas, or recreational areas, in a staggered manner, without having to deal with crowds of people, is a key factor for resilience and improvement of territories.

The population in rural areas, cities with low population density and the suburbs of large cities made greater use of green spaces (Rice et al. 2020; Uchiyama and Kohsaka 2020). The studies have mostly been conducted in large cities, as is the case in the 6-country study by Ugolini et al. (2020). The results obtained therefore have a bias towards the study of urban green spaces and the urban population, with lifestyles and routines different from those of the rural population. In this sense, it would be necessary to study the relationship between green spaces and the rural population in the context of the pandemic. It has been recorded that the rural population has also suffered a deterioration in their mental health (Shafi et al. 2021) but it is less than that detected in the urban population (Liu et al. 2021).

It has also been recurrent that social distancing measures have not been able to be enforced in all neighborhoods or public spaces (Nguyen et al. 2020; Shoari et al. 2020), so there is a need to provide all neighborhoods and cities with a percentage of green spaces to allow the population to enjoy leisure time in crisis situations such as pandemics. No relationship was found between the economic level of the study countries and the level of access to green spaces. The relationship with green spaces has been influenced by pandemic containment measures, largely taken in local and regional contexts. In the local context, within and between cities in the same country, socioeconomic variables have indeed influenced the availability of green space (Wu and Kim 2021) and thus access to green space. Further studies have shown that pandemic conditions have not significantly changed access to green space, but that it is still socioeconomic attributes that influence the use of green space (Spencer et al. 2020; You et al. 2020). Therefore, it is necessary to deepen the existing relationships between socioeconomic levels and the availability of green spaces or the presence of greenery in the neighborhoods, which is considered a environmental justice issue, even more since the COVID-19 crisis has affected families in economic terms (Andrade et al. 2022).

One of the most relevant features of the pandemic has been the changes in mobility patterns. In terms of modes of transport, there has been a reduction in motorized transport in favour of cycling (Venter et al. 2020) and access to green spaces is over short distances is usually on foot. In high-density cities with a deficiency of green spaces, people visited green spaces on the periphery or outside the neighborhood by private car (Ugolini et al. 2020). Therefore, having green spaces close to home will also help to reduce car trips (Day 2020). Mobility data have also been a key factor to analyzing access to green spaces. These data have been provided by private companies, especially Google Mobility, to be used to improve knowledge during the pandemic (Yap et al. 2022). In addition, internet searches were also examined to assess the population's interest in nature during the pandemic. The study by Rousseau and Deschacht, (2020) used information from Google Trends to assess web searches, which is in line with other recent studies such as Souza et al. (2021) that assessed internet search volume to quantify public interest in green spaces.

The evidence from the present review is consistent with previous and subsequent studies arguing that the COVID-19 pandemic will be a turning point in the city planning (Fasolino et al. 2020) and specifically in natural urban spaces (Noszczyk et al. 2022). The need to strengthen the relationship between nature and humans is one of the priorities highlighted after the pandemic (Bayulken et al. 2021; Geary et al. 2021). Landscape ecology has several implications for green spaces, including analyzing the impact of landscape on vegetation biodiversity and how this biodiversity affects access to green spaces. In addition, landscape ecology explores how the availability of green space in cities could have a positive impact on the physical and mental health of the population. Finally, landscape ecology can provide different theories on how the design and accessibility of these spaces influence community cohesion and human relations (Grafius et al. 2018; Tian et al. 2014).

Although green spaces perform functions that improve the quality of life and well-being of people, these spaces do not provide benefits in all situations or contexts; for example, Liu et al. (2019) evaluated the correlation between green spaces and three types of epidemics (dysentery, tuberculosis, and malaria) and determined that the association could even be

the opposite. Population increases in the process of urbanization—accompanied by the creation of green spaces—could increase the risk of tuberculosis and malaria, in addition to attracting insects such as mosquitoes to urban areas. In terms of dysentery, increased humidity due to the existence of green spaces can lead to a higher incidence of this disease.

There is a lack of studies analyzing the landscape and environmental implications of the COVID-19 pandemic on the maintenance and state of conservation of green spaces. This type of work has been carried out in mostly rural or natural settings, such as the study by Piquer-Rodríguez et al. (2023), which analyses the observed effects of the pandemic on landscapes. Future studies should aim to analyze the characteristics that green spaces should have to meet the needs of citizens during crises such as the COVID-19 pandemic, paying attention to social inequalities in access and use of these spaces. This research will allow us to create evidence that will help to plan and manage these green spaces. This review of the scientific literature has had the strength of including studies that—in different geographical areas and with different approaches—addressed the relationships with green spaces/nature during the COVID-19 pandemic. Likewise, the methods used to analyze these relationships have been diverse, making the results extracted robust, since they are the result of the application of diverse working methodologies. Furthermore, this study focuses on the first year of the pandemic, which has had the greatest impact on the use of and access to green spaces. Green infrastructure planning through landscape ecology management can improve the resilience of cities, serving as a barrier to adapting to climate change, providing agricultural supplies, and improving their potential use and access in cities during crisis situations (Pamukcu-Albers et al. 2021). As such, landscape ecology theories, through their holistic relationship with landscape epidemiology and other disciplines, provide a conceptual framework for explaining, describing, and anticipating the emergence and spread of these communicable diseases (Azevedo et al. 2020).

It is also necessary to recognize the limitations of this study. These include the country bias of the studies included in this literature review. The predominance of scientific studies in high-income countries means that we do not analyze in depth the reality of low-income countries. It should be noted that only two studies included South America (Geng et al. 2020; Pouso et al. 2020) and one Africa (Geng et al. 2020). Therefore, the results obtained cannot be extrapolated to the whole world. Similarly, it should be borne in mind that the pace of the pandemic has not been homogeneous in all countries, so that countries have gone through different waves of the pandemic in different periods, has established different restrictive measures and have experienced several levels of infection and mortality. In the same way, the COVID-19 pandemic is a recent and time-varying phenomenon, so the results obtained from the review may be modified by the publication of subsequent articles. Another challenge with this review was the inclusion of a wide range of journal types, with different methodological approaches (e.g., medical journals, planning journals, environmental studies journals), making it challenging to compare across studies. Nevertheless, the articles were selected according to the inclusion criteria and validated by the authors for their relevance and consistency. These listed factors have affected the reported results on the interaction between people, green spaces, and nature during the COVID-19 pandemic and should be considered when interpreting the results.

Conclusions

During the first year of the COVID-19 pandemic, the number of green space users increased compared to the prepandemic period in most of the analyzed studies. After periods of peak increased risk of COVID-19 infection, when containment measures allowed, the use of green spaces increased primarily due to the inability to access other recreational spaces, attracting new users. Users who had access to green spaces were in contact with sounds and smells that brought them positive feelings or emotions. The most visited green spaces were the ones close to the neighborhood, accessible by active travel modes, such as walking or cycling. In those cases where access to green space was not possible due to containment measures, exposure to nature was replaced by indirect modalities, such as views of nature from the home. Green spaces promote resilience to the effects of the COVID-19 pandemic, so in times of crisis, it is necessary to provide easy and quick access to these public open spaces, which should remain open so that the

population can access safely while maintaining social distance.

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Data Availability All the studies analyzed are available in the databases referenced in the manuscript.

Declarations

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