What is the effect of the COVID-19 pandemic on the use of urban greenspace? A systematic review protocol

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1. Background

COVID-19 lockdowns and subsequent travel and work restrictions have raised awareness of and have caused widespread discussions on the benefits and limits in availability of green spaces near residential areas (Berdejo-Espinola et al., 2021; Kleinschroth & Kowarik, 2020; Rice & Pan, 2021). It has been reported from many cities around the world that the use of greenspace was critically affected by the COVID-19 pandemic (COVID), including decreased uses due to restrictions to access greenspaces during lockdown periods, and increased uses afterwards (Burnett et al., 2021; Geng et al., 2021; Ugolini et al., 2020; Venter et al., 2020; Yap et al., 2022). While a narrative review of nature's contribution in coping with COVID is available (Labib et al., 2022), a systematic synthesis of the evidence on changing use of urban greenspaces and their importance to urban residents since the start of COVID is lacking.

With this review we aim to synthesize the global published evidence on changes in use and perception of urban greenspace in relation with different phases of COVID, the associated restrictive measures, and the consequences of these changes for future sustainable cities. If global evidence supports the hypothesis that a shift towards temporally or continuously higher demand for urban greenspaces has happened, this will have important implications for the future development of urban green infrastructure as a pathway towards healthy, sustainable and resilient cities. What matters here is both direct demand by people who visit green areas, but also indirect demand for green views from windows during strict lockdowns. COVID has led to a process of reconsidering urban space from

perspectives of health and ecology, recognizing the need for inclusive planning (UN-Habitat, 2021). As part of this, thresholds and administrative decisions for the provision of green space per capita (reviewed by Boulton et al., 2018) may need to be reconsidered to better factor in risks such as pandemics, where suddenly the space demands of people increase, both due to overall higher demand, but also in order to keep distance to each other. In preparation for future pandemics, but also for the general well-being of urban dwellers, our results will provide a potential justification (or not) for higher efforts in urban greening and in improving the accessibility of formal and informal urban greenspaces.

2. Objective

The objective of the review is to systematically review and synthesize the evidence on the global use of urban greenspace in relation with COVID, specifically focusing on changes in use due to the pandemic. In the review, we will use the following definitions:

- We define urban as all areas within the political borders of a settlement irrespective of its size
- We define urban greenspace as unbuilt areas, dominated by vegetation or water that lie within, are intersected by or directly tangential to the borders of settlements of any size, from villages to megacities. This includes public formal or planned greenspaces such as parks and forests as well as informal or unplanned greenspaces, such as vacant areas and vegetated street sides. We include private and semi-private areas such as home gardens, balconies and rooftops in this definition.
- We define the use of greenspace as any kind of activity related to leisure or work, including direct physical movement taking place inside greenspace as well as indirect use by looking at it from the outside, for example through a window from inside a house.
- The target group of people is the global human population living in settlements of any size. The relevant group of stakeholders are actual and potential users of greenspaces and their representatives as well as urban planners, administrators and decision-makers.
- We define accessibility to urban greenspace as the distance-dependent availability of greenspace combined with the ratio between available area and number of potential users and in relation with varying mobility restrictions.

Based on these definitions, we outline the following primary research question (a) and secondary questions (b and c), each with underlying testable aspects as bullet points:

2.1. Research questions

a) What is the effect of COVID on the use of urban green spaces?

- Reported magnitude of change in duration, frequency, and timing of uses
- Type of use: leisure, sports, dog-walking, gardening, exploring nature, working, window-watching
- Location and spatial distribution of the reported changes
- Changes in the social, cultural, demographic composition of users
- Size of the addressed urban area: From rural village to megacity
- Location of the greenspace within the urban fabric: high density center, low-density developed areas, near-natural areas
- Type of greenspace: All, including formal and informal, public and private, designed and wild greenspaces, natural remnants. For example, parks, private gardens, community gardens, forests, street sides, vacant areas, cemeteries, watersides, agricultural areas, balconies and roof gardens, vertical greening (the latter two relevant e.g., for the view from windows)
- Changes in use of different types of greenspaces: Features and characteristics that were on higher or lower demand during COVID (e.g. related to size, greenness, availability of park furniture)
- Temporality of changes: before COVID outbreak, during first lockdown, later phases of the pandemic

b) What methods have been used to detect changes and effects?
    - Interviews, tracking, observations, indicators derived from online activities
    - Availability of before-after data vs. perceived changes

c) What is the coverage of available studies?
    - Geographic distribution
    - Relationship/ correlation with overall COVID cases or types of mobility restrictions

We defined study components using the following PECO (Morgan et al., 2018) terms:

- Population: Human population globally living in urbanized areas that had lockdowns during COVID
- Exposure: Use of greenspaces
- Comparators: Before vs. during and after lockdowns
- Outcome: Changes in use, behavior and perception of greenspace (specified under 2.1 a)

3. Methods

The review will follow the guidelines of the Center for Environmental Evidence (https://environmentalevidence.org/) and comply with the ROSES reporting standards (Haddaway et al., 2018).

3.1. Search terms and languages

The initial searches will be carried out in six languages (English, German, Spanish, Portuguese, French and Chinese) to reduce bias and ensure a wide geographical coverage of potential studies. Together with native speakers and after series of initial scoping searches, we defined the following sets of keywords composed by #1 type of settlement, #2 type of the greenspace, #3 COVID-19 related terms, #4 different usage terms. The search string was developed in English and subsequently translated into other languages. We improved the list of English search terms through a machine learning strategy with the R package litsearchr (Grames et al., 2019). During this procedure, all abstracts, titles and keywords from the first 1000 hits in Web of Science were text-mined to generate a list of frequently mentioned keywords, sorted by strength. The outcome was a list of 2081 terms, from which we identified seven that we added to the initial search string for improvement. The final search string #5 combines the different search terms under different elements (#1-#4) using Boolean operator AND. Search string #4 will be left out from the searches in other languages than English as only few studies are available and they are not captured with such a specific search string. The asterisk (*) is a wildcard character that represents any group of characters, including no character. Quotation marks are used to search exact phrases. Below the search strings for different languages are presented.

3.1.1.English

For publication databases the search string is the following (in Web of Science format, TS=topic search):

#1 TS = (urban* OR town* OR settlement* OR "populated area*" OR agglomeration* OR "built environment*" OR city OR cities OR village* OR "public space*")

#2 TS = (green* OR park* OR "open space*" OR "natur* area*" OR “urban natur*” OR garden* OR forest* OR vegetate* OR ecosystem* OR backyard* OR cemeter* OR graveyard* OR waterside* OR river* OR “roof garden*” OR balcon* OR “vertical green*” OR agricultur* OR “protected area*” OR “nature reserve*” OR “national park*”)

#3 TS = (pandemic* OR COVID OR COVID-19 OR corona* OR coronavirus OR SARS-COV-2 OR lockdown* OR “social distancing” OR "Severe Acute Respiratory Syndrome Coronavirus 2" OR "2019-nCoV")

#4 TS = (use OR need* OR benefit* OR recreation* OR health OR service* OR motivation* OR mobility OR attitude* OR leisure OR walk* OR hike OR hiking OR running OR play*

OR window* OR view* OR gardening OR jogging OR sport* OR “physical activity” OR outdoor*)

#5 TS = #1 AND #2 AND #3 AND #4

Google Scholar (256 characters search limit):

(urban* OR town* OR city OR settlement*)

AND (green* OR park* OR "open space*" OR "natural area*" OR garden* OR forest*)

AND (pandemic* OR COVID OR COVID-19 OR corona* OR SARS-COV-2)

AND (use OR benefit* OR recreation* OR leisure OR activ* OR view*)

3.1.2. German

(urban* OR stadt* OR Ort* OR agglo* OR siedlung*)

AND (grün* OR park* OR natur OR wald OR wälder OR vegetation* OR Ökosystem* OR garten OR gärten OR freiraum)

AND (pandemie OR COVID* OR corona* OR SARS-COV-2)

3.1.3. Spanish and Portuguese

(urbano OR ciudad OR cidade OR asentamiento)

AND (verde OR parque OR natur* OR bosque OR floresta OR vegetation OR ecosistem* OR jardin OR “espacio libre”)

AND (pandemia OR COVID OR COVID-19 OR corona* OR SARS-COV-2)

3.1.4. French

(urbain OR ville OR municipalit* OR peuplement)

AND (vert OR parc* OR natur* OR forêt* OR vegetation OR ecosist* OR jardin* OR "espace extérieur")

AND (pandemi* OR COVID OR COVID-19 OR corona* OR SARS-COV-2)

3.1.5. Chinese

Google Scholar

(城市 OR 城镇 OR 都市)

AND (绿化 OR 绿地 OR 公园 OR 花园 OR 生态系统*)

AND (疫情 OR 新冠* OR 冠状病毒 OR 肺炎 OR COVID*)

CNKI (中国知网)

Based on Advanced Search:

Subject 城市 + 城镇 + 都市 + 建成区

AND Subject 绿地 + 公园 + 绿化 + 花园 + 林地 + 草地

AND Subject 疫情 + 冠状病毒 + 新冠 + COVID + 肺炎

3.2. Estimating the comprehensiveness of the search

We pre-selected a list of 20 key papers (provided in SI) that we considered as key for the subject and that cover different subject domains and regions of interest. We extended the set of English keywords until all 20 papers were included in a search on Web of Science.

3.3. Bibliographic databases

We will search Web of Science (all databases using ETH Zurich library subscription), and Google Scholar to identify publications in all languages. We will additionally search Scopus and CABI in English using the same search string as for Web of Science and CNKI (www.cnki.net) in Chinese. All searches (including grey literature searches) will be restricted by date from 1 January 2020 until date of search. Search alerts will be set to retrieve papers published after the initial search until data extraction begins.

3.4. Additional searches

We will carry out additional searches for grey literature with the same lists of keywords on Google and Baidu. We will use 'private mode' for internet searches to avoid the impact of previous browsing history and location on search results. The results will be organized by relevance and screened until no more relevant papers appear (Livoreil et al., 2017). The date and number of hits received and searched will be recorded and included in the review report. In addition, we will read through reference sections of all articles included in the review as well as any relevant previous reviews on the topic to identify any potential additional articles.

3.5. Search record database

All articles found during the searches will be imported into Mendeley Desktop and duplicates removed. Due to the lacking functionality to export all records from Google Scholar, relevant articles

will be saved to “My library” by adding stars during a first screening phase directly on the website. These records will then also be exported to Mendeley for duplicate removal. The full database will be uploaded to Rayyan (Ouzzani et al., 2016) for screening. References selected for full-text screening will again be managed in Mendeley Desktop. Data will be extracted to Excel.

4. Article screening

We will screen studies based on the eligibility criteria in two stages: First title and abstracts and then full-text articles. Grey literature will also be screened in two stages: First through title and the two lines of text shown in Google Scholar, then based on full text. Articles retrieved from the publication databases will be screened independently by two people and their results compared as recommended by Frampton et al. (2017). For consistency checking, the team will screen first 30 articles together to ensure common understanding at both stages of screening. Here, any necessary clarifications of the screening criteria will be done. After the initial 30 articles screening will be independent. Based on experience, this is enough for screeners to arrive to a shared understanding and hence, ensure consistency of screening. Screening decisions for the next 70 articles will be checked by another screener to further ensure screening criteria is applied consistently. If screeners do not seem to arrive on consistent decisions in applying the screening criteria during the first 30 articles, then double screening continues until criteria is consistently applied.

If there are multiple articles from the same site (i.e. linked articles), they will be appraised together to avoid inclusion of duplicate data following Frampton et al. (2017). True duplicate studies will be removed, and the rest will be screened as a single unit to consider all available data pertinent to the study when making eligibility decisions.

Any articles where the screener is unsure about inclusion/exclusion will be included to the next stage. Any discrepancies in screening results will be discussed among the team and decisions consolidated. The review may include articles published by the authors of the review. Their inclusion in the review at the screening and critical appraisal stage will be determined by the other authors in accordance with the eligibility and appraisal criteria.

After checking consistency of screening decisions based on English articles for all screeners, articles in other languages than English will be screened by a single person only due to language limitations. Articles from publication databases will be screened first and hence, it is assumed that the consistency of screening decisions achieved in English will be applicable during screening in other languages. If a screener is unsure about any article during the screening process, they will mark the article as ‘unsure’ and it will be discussed among the research team members.

4.1. Eligibility criteria

The eligibility criteria are based on the PECO components and study languages (Table 1). We will provide a list of articles excluded at the full text stage with reasons for exclusion.

Table 1. The eligibility criteria for screening.

Question element	**Eligibility criteria**
Population	*Included:* Studies that were conducted in a country that had lockdown during the COVID pandemic
Exposure	*Included:* Studies that looked at the change in use of urban greenspaces
Comparator	*Included:* Studies that have reference to the time before and during or after lockdowns.
Outcomes	*Included:* Actual or stated uses of urban greenspaces or outcomes on health/well-being that directly relate to the use of greenspaces
Data	*Included:* Studies with quantitative or qualitative data on the outcomes.
Languages	*Included:* English, Chinese, German, Spanish, Portuguese, and French

Studies not fulling the eligibility criteria will be excluded. In addition, the following studies will be excluded:

- Review studies
- Studies based on anecdotal evidence
- Studies where changes in use of urban greenspace since COVID are assumed as a given (no data linked with the change).

4.2. Study validity assessment

We will conduct a critical appraisal of methods used in the studies. To ensure consistency, all reviewers will work on the first five studies together to clarify any discrepancies. Given that COVID was not anticipated and affected large parts of the world, we do not expect to find any gold-standard methodologies such as randomized control trials or otherwise fully controlled studies. Rather, the critical appraisal will first consist of differentiating between studies that collected data of some sort and others that simply assumed differences based on anecdotic evidence. The latter type of studies will be excluded from the review.

For those that report data, we will assess internal validity, i.e., the scientific quality and the potential biases in the methodology based on the following criteria (Brooks et al., 2013; Macura et al., 2015):

Knockout criteria:

- Are there clearly stated research questions? (Yes, seemingly Yes, No)
- Are methods clearly described? (Yes, seemingly Yes, No)

Additional criteria:

- Are methods appropriate for the research question? (Yes, seemingly Yes, No)
    - Sampling methods (e.g. number of observations, geographical distribution)
    - Statistical analysis (e.g. clearly described, data fit for model)
- Inclusion of control cases in the study (Yes, seemingly Yes, No)
- Have authors considered confounding variables (e.g. temporal distribution of observations, weather conditions: Yes, seemingly Yes, No)
- Have authors included confounding variables in the data analysis? (Yes, seemingly Yes, No)

Based on the ranking in the questions above, studies will be coded in three validity classes (low, medium, high). Studies that do not fulfil the knockout criteria (Answer for either of the questions is "No") will be considered of low quality. Studies that do not score "No" for any or the additional criteria will be considered high, studies that do not score "No" for two or more additional criteria will be considered medium validity. During quantitative synthesis, high quality studies will be assigned higher weight than low quality studies. Where feasible, we will also conduct sensitivity analyses without low quality studies to see their influence on the results. In case no papers of high validity will be found, we will distribute the weighting between medium and low studies.

External validity (i.e. the generalizability of a study to the study question of the review (Murad et al., 2018)) will be assessed at the full text screening stage based on the following criteria:

- Geographical location
- Type of greenspace
- Socio-cultural setting of the study

- Type of use

5. Data extraction

We will extract study metadata (author, publication year, etc.) and data on study outcomes to answer all sub-aspects specified under the review questions (Table 2). In addition, data on potential effect modifiers and sources of heterogeneity will be extracted. If an article contains independent results from more than one study, these will be treated as separate studies in data extraction.

Consistency between different data extractors will be checked by working on the first 5 articles together to clarify any potential discrepancies. Extracted data records will be made available as additional files. We tested the approach with three exemplary studies and assessed the feasibility of finding this kind of data in the given body of literature. Data extraction took ca. 2-3 hours per paper.

Table 2. Data on outcomes and potential effect modifiers to be extracted under different review questions.

Question	**Attribute**	**Categories**	**Unit**	**Feasibility of finding data**
Change in greenspace use	Frequency	Increase/ decrease/ no change	Number/ percentage of respondents/ users	High
	Duration	Increase/ decrease/ no change	Number/ percentage of respondents/ users	Low
	Timing	Time of day	Number/ percentage of respondents/ users	Low
	Perceived importance	Increase/ decrease/ no change	Number/ percentage of respondents/ users	Medium
	Location and spatial distribution	Distance from home	Number/ percentage of	Medium

			respondents/ users	
	Type of use	Cumulative list of activities	Number/ percentage of respondents/ users	High
	Composition of users	Group size	Number/ percentage of respondents/ users	Medium
	Social/cultural composition of users	Demography, social status, ethnicity, gender, etc.	Categorical	Medium
	Type of greenspace	Cumulative list of greenspaces	Categorical	High
	Urban area size	Based on number of inhabitants	Categorical	High
	Location of the greenspace(s) in the urban fabric	High density center, low-density developed areas, near-natural areas	Categorical	Low
	Temporality of change	Before COVID outbreak, during first lockdown, later phases of the pandemic	Categorical	High
Underlying methods	Type of study	Interviews, surveys, tracking, observations, indicators derived from online activities	Categorical	High
	Type of data	Before-after, perceived changes	Categorical	High
	Study duration	Start and end of observation period	Dates	High
	Sample size		Total number of respondents/ observations	High

Geographic location and coverage	Country	List of countries	Categorical	High

6. Potential effect modifiers

As the review covers a range of green spaces, geographical locations and different socio-cultural settings, heterogeneity between studies is expected. A list of effect modifiers and their coding is provided as part of the review questions (under section 2) and under data extraction (section 5). These lists were compiled based on consultations with external subject experts. This list is not exhaustive, but thought to contain the most important elements that are amenable to the analysis. It includes, for example, the following:

- Socio-cultural setting
- Size of the addressed urban area: From rural village to megacity
- Location of the greenspace within the urban fabric: high density center, low-density developed areas, near-natural areas
- Type of greenspace
- Location and spatial distribution (distance from home)
- Strictness of lockdown

7. Data synthesis

We will produce a narrative synthesis describing the evidence base. We will use various data visualisations, such as maps and plots, to illustrate the extent of evidence related to the study objectives and knowledge gaps that exist.

If there is enough evidence to conduct a meta-analysis, then a quantitative summary of those studies will be produced. Study effect sizes will be standardized and weighted appropriately. We will assess influence of potential biases through funnel plots and sensitivity analyses, including 'trim and fill' method to detect and where necessary adjust for publication bias. We will produce forest plots to visualise effect sizes and 95% confidence intervals from individual studies. Analyses will be conducted in R (R Core Team, 2019).

7.1. Follow-up analyses

Given the urgency of COVID, we expect that many of the publications cover only a relatively short period of time. Depending on the type and comprehensiveness of the overall review results, we will

follow-up on previous analyses based on Google Trends search interests to prolong those time series. For example, Kleinschroth & Kowarik (2020) and Roll et al. (2021) used Google search terms related to activities and features that are typically associated with urban green spaces, as indicators for changed interest and demand during and after lockdown phases. We will look for search terms and their German translations such as “go for a walk”, “get some air”, “gardening” and “outdoor exercise”. Further, we will include search trends on the names of common garden birds and plants. Google Trends normalized data with a worldwide search area will be exported from 2017-2022 in weekly intervals and then used for before-after comparisons.

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Annex: Article test list for the use of urban greenspace since the COVID pandemic

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