



Streetscapes as Surrogate Greenspaces During COVID-19?

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In 2020, the spread of COVID-19 (SARS-CoV-2) globally led to severe crisis, disruption and hardship in both private and public life. In such times of distress, access to urban greenspaces is essential for physical and mental wellbeing. However, globally implemented lockdowns deprived many people of freely visiting greenspaces. Inequality in access to urban greenspaces was apparent at global scales. Consequently, many people took to streets for outdoor activities due to its easy accessibility. We, therefore, aimed to study the usage and relevance of streetscapes for outdoor activities during a crisis. We hypothesised that streetscapes supported diverse outdoor activities, functioning as surrogate urban greenspaces. We distributed an online questionnaire to over 400 international respondents. Our results clearly showed that people used streetscapes during this period for a variety of activities, many of which were also reported as their main physical activity. Walking was the most frequent activity in streetscapes globally, and independent from sociocultural characteristics. Other activities reported such as jogging and cycling also aligned generally with main physical activities of people, but differed between countries and people's sociocultural background. In summary, more than one third of respondents from lower-income countries reported not having had access to a greenspace, whereas 8% reported the same in high-income countries. Our results highlight the important role of streetscapes in facilitating people's regular physical activities during the pandemic. Recognising streetscapes as important public outdoor spaces within residential neighbourhoods could help counteract the inequality in greenspace access, an issue that seems more relevant than ever before.

Keywords: COVID-19 (SARS-CoV-2) pandemic, equal greenspace accessibility, human wellbeing, open space usage, recreational outdoor activity, urban green infrastructure, urban greenways, vegetated streets

OPEN ACCESS

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Specialty section:

This article was submitted to
Urban Greening,
a section of the journal
Frontiers in Sustainable Cities

Received: 17 May 2021

Accepted: 28 June 2021

Published: 26 July 2021

Citation:

Fischer LK and Gopal D (2021)
Streetscapes as Surrogate
Greenspaces During COVID-19?
Front. Sustain. Cities 3:710920.
doi: 10.3389/frsc.2021.710920

INTRODUCTION

The global spread of COVID-19 (SARS-CoV-2) as a pandemic has led to severe crisis, disruption and hardship in private and public life (UN, 2020; WHO, 2020). People have been asked to, and in some regions required to, stay at home as much as possible to contain the spread of the pandemic. With partial or complete lockdowns implemented globally, going outside for getting fresh air or engaging in physical exercises was in many places restricted to few hours a day, often as close to one's home as possible. Getting outdoors, therefore, in many places was limited to activities within the close surroundings.

Recreational use of public greenspaces and natural areas rose due to reduced mobility within one's city along with travel restrictions, both internationally and locally (Venter et al., 2020). People were also encouraged to spend time outdoors to ensure sound mental and physical health in general

(Slater et al., 2020). Many urban greenspaces were thus functioning as important places for diverse activities in people's daily lives (Kleinschroth and Kowarik, 2020; Ugolini et al., 2020; Yang et al., 2021): places for mental recovery and physical activity, and later, increasingly as places where social gatherings were allowed or at least tolerated. Nevertheless, to ensure social distancing, some cities decided to temporally or partially close urban parks, playgrounds and sports grounds for the public, leading to an increased pressure on other open spaces such as squares and streets. This situation highlighted the unequal distribution of and access to urban parks and gardens in cities during the pandemic (Shoari et al., 2020; Dushkova et al., 2021). Vice versa, home gardening showed an increase in its popularity, and both physical and mental health benefits are associated (Corley et al., 2021). This phase of worldwide crisis emphasised the importance of both formal green and open urban spaces, such as parks and gardens, and spaces within the immediate surroundings of people's homes for regular activities. The latter in particular were often repurposed and reimagined for recreation, e.g., people playing at their doorsteps, in front of their houses and on their streets (**Figure 1**).

Although traditionally, the primary function of streets is to be mobility corridors, they have great potential to function as an easily accessible and—often green—outdoor space for residents. Green elements such as street trees can contribute significantly to the quality of outdoor space within streetscapes. In Melbourne, for example, street greening contributes to about one third of the city's greenery (Marshall et al., 2019). Yet, streets are rarely recognised as part of green spaces within cities when it comes to recreational activities—even if in some cities, streets are intended to be constructed as green corridors. While historically, recreational aspects were included in street design by planning streets as tree-lined alleys and boulevards in many metropolises (Jacobs et al., 2002; Feng and Tan, 2017), there seems to be resurgence of this concept to fulfil new green functions within recent urban agendas (e.g., streets to parks project in Yarra, Melbourne metropolis; Baldauf et al., 2020). Globally, it is necessary to complement traditional greening concepts with new, inclusive ways to urban greening (Mata et al., 2020), and land use types such as streetscapes could have great potential.

Within street greening, while avenue trees have been widely studied around the world (e.g., Nagendra and Gopal, 2010; Kendal et al., 2012; Breuste, 2013), other components of street greening including tree pits (Omar et al., 2018) and spontaneous roadside vegetation (Bonthoux et al., 2019) are gaining attention. Recent research on mobility behaviour and its relation to different green levels is exploring the influence of such natural elements in streets on user preferences and behaviour. For example, the connection between street greening and cycling (Ghekiere et al., 2015; Nawrath et al., 2019) or walking (Lu et al., 2018) revealed mainly positive relations between green elements and street preference for physical mobility, also within specific groups of society such as the elderly (He et al., 2020).

Much before the pandemic, studies showed that being outdoors and active often had positive health outcomes to perceived health, including physical and mental relief and stress reduction (see, e.g., Keniger et al., 2013; Hartig et al., 2014). Even

short exposure to natural surroundings could translate to stress relief (Tyrväinen et al., 2014). Positive health benefits have been shown especially for gardening (Soga et al., 2017) and active commuting through natural areas (Zijlema et al., 2018), and green streets (de Vries et al., 2013). Since the onset of COVID-19, first studies determined that urban greenery had positive effects on physical activity duration within neighbourhoods and at home (Yang et al., 2021; $N = 661$ for Hong Kong), and self-reported physical health improved after visiting urban parks (Xie et al., 2020; $N = 386$ for Chengdu, China). Experiencing blue-green spaces during a lockdown also proved beneficial for mental health (Pouso et al., 2021; $N = 5218$ in nine countries).

In a pandemic situation, which ranged from limited public life to complete lockdowns, we aimed to find out how streets support people's outdoor needs, and whether these relate to their sociocultural backgrounds. We postulate that during the COVID-19 pandemic, people used streetscapes for outdoor activities usually associated with traditional urban greenspaces such as parks. We hypothesise that streetscapes offer an exceptional outdoor environment for recreational activities at people's doorsteps. With this in mind, we conducted a questionnaire survey to answer the following research questions: (1) What were the main activities people engaged in on urban streetscapes during the initial months of the pandemic? (2) Did the respondents' sociocultural background influence their choice of activity on streets? (3) Did these activities relate to people's affiliation to urban greenery? (4) What were their preferences with regard to green street corridors?

METHODS

Questionnaire Survey

We developed a quantitative questionnaire survey assessing (a) activities carried out on streets during first wave of COVID-19 partial and complete lockdowns in relation to main physical activities people performed, (b) respondents' affiliation to urban greenery, (c) their sociocultural background, and (d) their preferences with regard to green street corridors (**Table 1**; **Supplementary Table 1**). The survey was conducted in May and June 2020, when most countries around the world implemented partial or complete lockdowns in response to the rising COVID-19 pandemic. Most survey questions were based on previous studies on preferences of urban green that incorporated in depth sociocultural background of people in diverse geographic regions (Fischer et al., 2018a) and in relation to greening in streets (Nawrath et al., 2019). The questionnaire was pre-tested by 21 international students and the preliminary version was corrected based on their suggestions and feedback. The standardised questionnaire (**Supplementary Table 1**) was completed in English either online or through personal interviews by the international students. In total, 173 personal interviews (telephonic or web conferencing) were conducted by the students (minimum five interviews each) as part of a course requirement at the university. The online questionnaire was distributed initially through the authors' and students' professional and personal networks by email and social media (WhatsApp, etc.). Respondents were then requested to



FIGURE 1 | During the initial months of COVID-19 in Europe, access to urban greenery including playgrounds was strictly forbidden in many regions (A). During times of social distancing, many people creatively used their close surroundings for physical activities and outdoor recreation such as for playing tennis on the street across a parking gate (B), and using street trees for gymnastics (C). Other examples are the establishment of pop-up bike lanes in inner city street corridors (D), interim playgrounds and pocket parks within residential areas, along urban streets. Picture credits: L. Fischer.

distribute further to their contacts, following snowball sampling methodology, yielding 255 interviews. As a result, the survey sample consisted of 428 respondents from 136 urban areas and 39 countries. Male and female respondents were almost equally distributed (49 and 51%, respectively) and above 18 years of age.

Data Preparation

To identify the primary street activity, respondents were given seven different options to choose from and asked to select the main activity performed; the main physical activity was assessed by an open-ended question (Supplementary Table 1). The answers gained from the latter were grouped in the same categories as used for primary street activity, and additional categories such as indoor workout. We described the sociocultural background of respondents using four variables (Table 1A; Supplementary Table 1): gender, age group, economic region of respondents' country of residence (categorised as high, upper-middle, lower-middle, low-income economies; World Bank, 2020), and population density of respondents' city of residence (UN DESA—United Nations Department of Economic and Social Affairs (Population Division), 2019). Since none of the respondents were from low-income economies, we omitted this category. Studies on other greenspaces have established the implications of respondents' affiliation to urban greenery in long-term planning and management (Fischer et al., 2018b, Nawrath et al., 2019). Accordingly, we characterised it through four variables (Table 1B; Supplementary Table 1): frequency of greenspace visits during first wave of COVID-19, type of greenspace accessed during first wave of COVID-19, gardening practises, and neighbourhood greenery in the respondents' surroundings. As background information, we assessed

respondents' general access to greenspaces during first wave of COVID-19 and whether they used streets to commute to work (Supplementary Table 1). We defined respondents' preferences with regard to green street corridors through three variables (Table 1B; Supplementary Table 1): their choice of route for walking, choice of route for cycling, and type of street greening they preferred.

Descriptive and Statistical Analyses

To determine if there were similarities between responses to survey questions on respondents' primary street activity and main physical activity, we created a Sankey diagram (Figure 2) by using the online tool SankeyMATIC (www.sankeymatic.com). Sankey diagram shows flow of activities between the primary street activity and main physical activity wherein the width of each flow is based on its proportional frequency. We used Pearson's Chi-squared test to detect associations between streetscape activities (i.e., walking, cycling, jogging, dog walking, gardening, socialising, and others) and (a) respondents' sociocultural background (i.e., gender, age group, economic region of country and population density of city), (b) affiliation to urban greenery (i.e., frequency of greenspace visits, type of greenspace accessed, gardening practises, neighbourhood greenery), and (c) respondents' green-street preferences (i.e., choice of route for walking/cycling and type of street greening preferred). To determine the relevance of streetscapes as surrogate greenspaces, we checked for association between type of greenspace accessed during first wave of COVID-19 and regional characteristics (i.e., population density and economic region). When expected values fell below the minimum of five, Fisher's test was applied. All statistical analyses were performed using R software, v.3.6.0 (R Core Team, 2019).

TABLE 1 | Streetscape activities of respondents ($N = 428$) during the first wave of partial and complete COVID-19 lockdowns, in relation to (A) their sociocultural background and (B) their affiliation to urban greenery.

	Street activity (%)									Chi ²	p	F
	n (#)	n (%)	Walking	Cycling	Jogging	Dog walking	Gardening	Socializing	Others			
Total	428		60	14	11	5	2	2	6			
(A) Sociocultural background												
Gender										27.43	***	***
Male	209	51	52	20	16	3	1	2	6			
Female	219	49	68	8	7	7	2	3	5			
Age group										36.08	**	**
18–25	169	39	63	12	12	7	1	3	2			
26–40	186	43	56	16	13	5	2	3	6			
41–55	38	9	55	18	8	0	0	3	16			
Above 55	35	8	71	6	0	6	0	9	9			
Economic region (country)										73.75	***	***
High	292	68	58	18	15	3	1	2	3			
Upper-middle	67	16	57	4	3	19	1	4	10			
Lower-middle	69	16	74	4	1	1	3	4	12			
Population density (city)										37.12	***	***
Below 2000 per km ²	100	23	61	15	7	4	3	3	7			
2000–4000 per km ²	188	44	62	13	16	6	1	2	0			
Above 4000 per km ²	140	33	56	14	7	4	2	4	13			
(B) Affiliation to urban greenery												
Frequency of greenspace visit during COVID-19										66.81	***	***
Several times per week	168	39	58	15	16	7	0	2	2			
Once a week	92	22	65	20	9	3	1	0	2			
Less than once a week	87	20	60	11	10	3	3	6	6			
Never	71	17	61	3	4	6	4	3	20			
Don't know	10	2	40	20	10	10	0	10	10			
Type of greenspace access during COVID-19										35.56	**	**
Park	198	46	56	21	13	5	1	2	3			
Domestic garden	80	19	60	10	11	6	4	3	6			
Others GS	84	20	67	8	10	5	0	5	6			
No	66	15	64	3	8	6	3	3	14			
Gardening practises										37.90	**	**
Yes, in the garden	93	22	56	11	4	10	5	2	12			
Yes, on the balcony	115	27	59	17	10	7	2	3	3			
Yes, others	25	6	60	16	16	4	0	0	4			
No	195	46	63	13	15	2	0	3	5			
Neighbourhood greenery										22.93	n.s.	n.s.
More public GS	138	32	61	15	13	4	1	3	4			
More private GS	72	17	47	13	13	10	4	3	11			
Both public and private	150	35	62	13	8	7	2	3	5			
Few GS	68	16	68	12	13	0	0	1	6			

(Continued)

TABLE 1 | Continued

	Street activity (%)									Chi ²	p	F
	n (#)	n (%)	Walking	Cycling	Jogging	Dog walking	Gardening	Socializing	Others			
Total	428		60	14	11	5	2	2	6			
(C) Green-street preferences												
Change walking route to use green streets										33.49	n.s.	n.s.
Yes	272	64	61	13	11	6	2	2	4			
May be	121	28	60	16	12	5	0	2	6			
No	30	7	53	13	10	0	3	7	13			
Don't walk	5	1	40	0	0	0	20	0	40			
Change cycling route to use green streets										54.73	***	***
Yes	197	46	53	20	14	5	2	3	4			
May be	71	17	65	15	10	3	0	3	4			
No	29	6	45	28	21	0	0	0	7			
Don't cycle	131	31	72	0	5	8	2	3	10			
Type of street greening preferred										38.29	n.s.	n.s.
Street trees	66	15	62	12	6	6	2	3	9			
Low landscaping	10	2	70	10	0	10	0	10	0			
Both trees and low-landscaping	310	72	60	14	12	5	1	3	5			
Green walls/facades	15	4	67	13	7	13	0	0	0			
Water retention basin	12	3	17	25	25	8	17	0	8			
Others	15	4	67	13	13	0	0	0	7			

Values represent proportion of responds in each category, with *n* indicating the frequency. The results of the Chi² test show if there is an association between streetscape activities and sociocultural characteristics, or the variables describing affiliation to urban greenery. Significance levels (*p*-value) indicate associations between categories: ***p* ≤ 0.01; ****p* ≤ 0.001; n.s., not significant. *F* represents the significance of the Fischer test conducted when frequencies were below 5.

RESULTS

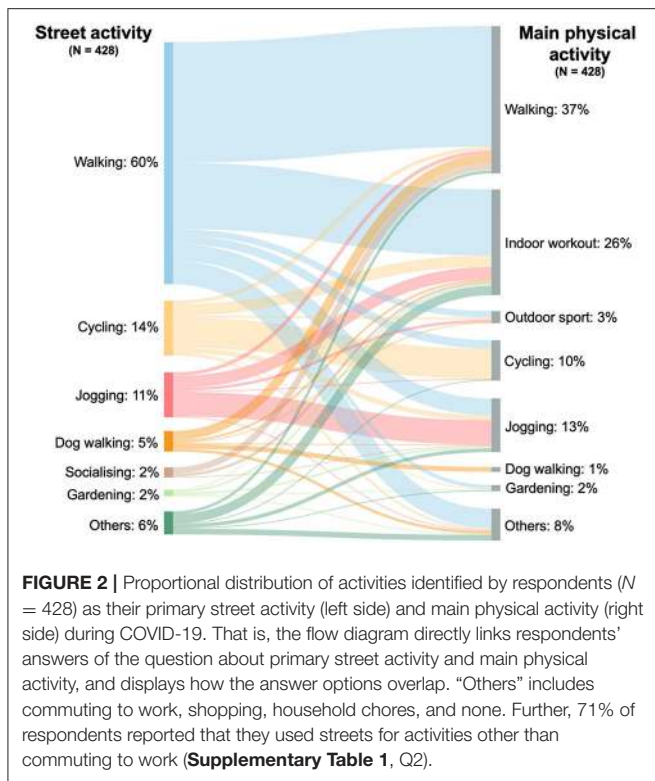
During the initial Covid-19 partial or complete lockdowns in 2020, for many people around the world streetscapes were important places to be physically active, right at their doorstep. Majority of our international respondents reported to use urban streets for walking (Primary street activity: 60% of respondents, **Figure 2**), and this aligned with their main physical activity (37%). For over 10 percent of our sample, both jogging and cycling were the main physical activity during the first global wave of COVID-19, and also the primary activity they performed in urban streets, respectively. Street gardening and socialising were the least reported primary street activity with <5% of respondents engaging in each. Further, 71% of respondents reported that they used streets for activities other than commuting to work (**Supplementary Table 1, Q2**).

With regard to sociocultural factors, we determined that irrespective of gender or age group, population density and economic region (lower middle-, upper middle-, and high-income economies), respondents' main street activity was walking (**Table 1**). We detected significant differences in people's street activities with respect to their sociocultural background (**Table 1A**): Gender and age group of respondents mattered for street activity they reported (**Table 1A**), with more females engaged in dog walking than men, and more men were cycling

and jogging. In cities with 2000–4000 inhabitants/km², more people were jogging and dog walking compared to cities with higher and lower population density. People engaged in different street activities within economic regions, such as a higher share of cycling and jogging in streets in high-income economies (18 and 15%, respectively) compared to lower-income economies (with <4% each).

Yet again, irrespective of respondents' general affiliation to urban greenery, walking was the most reported street activity (**Table 1B**). In regard to respondents' affiliation to urban greenery, our results show significant differences in street activities with regard to respondents' frequency of greenspace visit, the types of greenspace access, and whether they gardened or not (**Table 1B**). People that reported to garden regularly often also walked a dog on streets, and people not gardening regularly often jogged on streets. There were no differences in street activities for people with regard to their neighbourhood greenery.

With regard to green-street preferences, respondents were willing to change their walking (64%) and cycling (46%) routes to use green street corridors (**Table 1C**). Further, 72% of respondents preferred combination of street trees and low-landscaping elements for greening streets, followed by street trees alone (15%) and green façades (4%). Low-landscaping elements included grasses, perennials and wildflowers (see **Supplementary Table 1**).



As background information, we assessed the type of greenspace accessed generally by respondents during COVID-19. Our analyses showed that there were significant differences between economic regions and population density of cities with regard to people's access to greenspace (Figure 3). More than quarter of respondents from lower-middle and upper-middle economies reported not having had access to a greenspace (Figure 3A; 39 and 24%, respectively). Conversely, only 8% of respondents from high-income economies reported no access to greenspaces. This was also mirrored at the city-scale with majority of respondents from mid (2000–4000 inhabitants/km²) and low (below 2000 inhabitants/km²) density cities having access to parks, gardens or other greenspaces (Figure 3B).

DISCUSSION

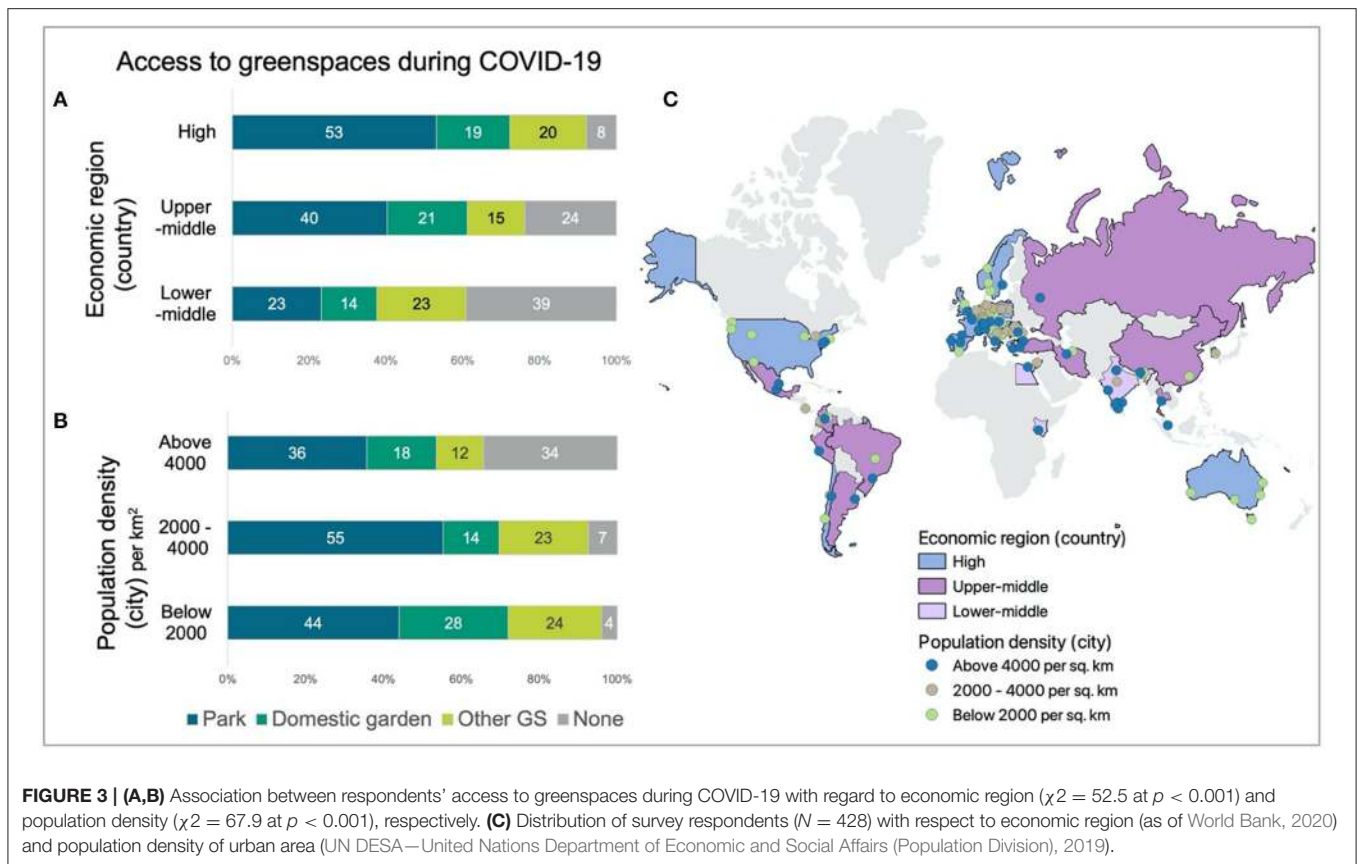
Our study elucidates that urban streetscapes support outdoor recreation during a global crisis such as the COVID-19 pandemic, and could possibly serve as a surrogate for greenspaces. With over 400 respondents from 136 urban areas and 39 countries, we demonstrate that urban dwellers use streetscapes in various ways, most often for walking, cycling and jogging. During partial or complete lockdowns in many of our international study regions, these activities generally aligned with the respondents' primary physical activity. Urban streetscapes, therefore, played an important role in facilitating people's regular physical activities outside, highlighting the need for recognising streetscapes as important public outdoor spaces. This was also mirrored in different sociocultural and geographic contexts (Table 1A). In Europe, several cities established temporary interventions to cater to the needs of residents for nearby

outdoor spaces during the pandemic. Practical examples in Glasgow (UK), Milan (Italy) and Stuttgart (Germany) showed that streetscapes could also temporarily be used for recreational activities with interim playgrounds and play streets or to support non-motorised traffic by establishing pop-up bike lanes or open streets (e.g., City of Glasgow, 2020; Comune di Milano, 2020; Landeshauptstadt Stuttgart, 2020). Streetscapes could be transformed from merely mobility corridors to outdoor spaces for people (Bertolini, 2020).

On an international scale, we showed that affiliation to green matters for streetscape activities as we determined an association between greenspace access, active gardening and frequency of greenspace visits and the types of activities performed within urban streets (Table 1B). From our results, we demonstrate that walking on the streets was a common physical activity, especially for people within cities of low greenspace access. For others with more greenspace access, streetscapes provided additional ground for outdoor activity (e.g., those that were gardening regularly used streets for walking a dog). Although there were no significant associations between neighbourhood greenery and respondents' street activities (Table 1B), people were willing to change their walking and cycling routes to use green streets (Table 1C). This is in line with the findings of previous studies that demonstrate that green corridors often play a positive role for people's route choice (Nawrath et al., 2019) or their physical activity levels (He et al., 2020) and walking behaviour (Lu et al., 2018). In this vein, studies before and during the pandemic proved that people with more affiliation to green showed e.g., higher life satisfaction (Bertram and Rehndanz, 2015; Soga et al., 2020).

Apart from walking, jogging and cycling, a small fraction of our respondents also engaged in street gardening. While we do not know whether this involved more landscaping aspects such as planting flowers or being engaged in urban agriculture, gardening in general shows important feedbacks for health (Soga et al., 2017). Besides health benefits from gardening as an outdoor physical activity, it also connects people to a green spot in their neighbourhood and has implications for their sense of place (Comstock et al., 2010). Urban gardening in streets such as planting in tree pits has been identified as an important activity that enables people to interact with nature in their close surrounding (Pellegrini and Baudry, 2014). Street gardening has great potential to improve quality of life in stressful times and should therefore be supported through formal and informal initiatives (e.g., tree pit greening projects in districts of Berlin; Bezirksamt Treptow-Köpenick von Berlin City of Berlin, 2018). This might be all the more important during a pandemic where people are engaging in urban gardening also for food provisioning (Cerde, 2020). Revealing how street greening could promote food supply in urban regions during times of crisis could be beneficial for planning cities that are "more just, green and healthy" (UN Habitat, 2021).

Given that a substantial proportion of our sample either had no access to traditional urban greenspaces such as parks (15%) during the first wave of the pandemic or rarely visited a formal greenspace (less than once a week—20%, never—17%; Table 1B), the role of open and informal spaces within residential neighbourhoods seems more relevant than ever before. Regional



differences (economic regions and population density) in access to greenspaces as seen in our study (Figure 3), and parallel studies (e.g., Dushkova et al., 2021) further accentuate the need to consider alternatives. Planning for green-street elements could be beneficial for a multitude of outdoor activities at present, and in the long run. This could help reduce unequal access to more formal urban greenspaces such as parks and gardens. The first wave of the pandemic has demonstrated that in many cities, and especially during fine weather, urban parks were full with people, making social distancing quite challenging (Douglas et al., 2020). Our results indicate that urban streets can act as additional open spaces and could even serve as an alternative greenspace.

Our study gives a snapshot of experiences during the unforeseen first wave of COVID-19 pandemic in early 2020. We are aware that our dataset has limitations with regard to sampling framework and sample size, and suggest that future research could benefit from including additional variables on socioeconomic backgrounds of respondents, and more in-depth surveys over a longer timeframe using a stratified sampling approach to increase regional representativeness. With generally limited information on how greenspaces can support public health in low- and middle-income countries (Nawrath et al., 2021), our study provides initial insights in these geographical areas, as >30% of our respondents reported from upper-middle and lower-middle economic regions. Further, retrospective questions regarding pre-COVID-19 period could be answered in follow-up surveys. Nevertheless, our study gives interesting

insights on usage of urban streetscapes in stressful times paving the way for further research in this direction for sustainable cities of the future, for which innovative ways of bringing natural elements into cities are essential (Mata et al., 2020).

There are many ways to increase the environmental and cultural benefits within streetscapes with regard to street greenery, depending also on the type of green element implemented. Green elements in streets range from street trees as common, formal, cultural elements (Kendal et al., 2012) to informal features such as wild growing herbs and grasses along street edges (Bonhoux et al., 2019). As a practical implication, our survey provides the insight that people preferred low-landscaping elements such as grasses, perennials, and wildflowers in combination with street trees as green-street elements. This is backed by previous studies in the context of spontaneous, wild growing vegetation in tree pits that people broadly supported species-rich vegetation (Fischer et al., 2018a). Also spontaneously growing, non-native tree species are widely accepted as greening element in streetscapes, especially when incorporated into a traditionally managed green street setting (Kowarik et al., 2021).

Recently, other street infrastructures are also being explored as potential places for greenery including green tram tracks (Sikorski et al., 2018) and green-roofed bus shelters (City of Utrecht, n.d.). Thus, such elements could not only contribute to greening a city, but also improve the quality of recreational outdoor spaces in an innovative manner. Subsequently, such

greening facilitates mitigation of urban challenges such as flood prevention or rainwater harvesting (e.g., through rain gardens and retention swales). In this regard, the potential of green streets and their usage as multifunctional spaces in different climatic zones and different cultural contexts shows great opportunity for planning liveable future cities around the globe.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because anonymity. Requests to access the datasets should be directed to leonie.fischer@ilpoe.uni-stuttgart.de.

AUTHOR CONTRIBUTIONS

All authors contributed to research design, data collection, data analyses, and manuscript writing.

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FUNDING

This publication was supported by the German Research Foundation (DFG) within the funding programme Open Access Publishing.

ACKNOWLEDGEMENTS

We thank the students for conducting the survey with us and all respondents for participating in the project, and Solène Guenat for helpful comments on an early version in lockdown times.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/frsc.2021.710920/full#supplementary-material>

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