Rethinking urban green spaces for urban resilience. Do green spaces need adaptation to meet public post-covid expectations?

The beneficial role of urban green spaces (UGS) and exposure to natural environments for city residents have been widely recognized and demonstrated (Bratman et al., 2019; Sikorska et al., 2020b). City planning for multifunctional UGS must not only take into account the health and well-being of their current residents but also be adapted to the emerging challenges, such as dynamic population growth (Haaland & van den Bosh, 2015) or climate change (Ramyar et al., 2021). Recently the COVID-19 pandemics challenged current approaches toward UGS planning in terms of ensuring residents' safety while maintaining the provision of benefits (Pouso et al., 2021; Galleguillos-Torres et al., 2022). The pandemics were a health hazard on an unprecedented scale affecting multiple aspects of peoples' lives, such as mobility patterns (Galleguillos-Torres et al., 2022) or recreational habits (Geng et al., 2021; Zwierzchowska & Lupa, 2021). Changes in UGS usage (Zhang et al., 2020) and their perception amplified by the anxiety towards airborne-spread diseases (Tansil et al. 2022) evoked a debate over post-pandemic UGS planning towards more resilient and sustainable cities and ensuring healthy lives and well-being – the United Nations Sustainable Development Goals (UN General Assembly, 2015). Preparing for comparable situations in the future is essential, for example the COVID pandemic could become an epidemic seasonal disease like influenza (Telenti et al. 2021). Overall, existing knowledge shows that the COVID-19 crisis presents an excellent opportunity for planners and policymakers to take transformative action to create more equitable, resilient and sustainable cities.

Undoubtedly the pandemic has had a disruptive impact on people's lives around the globe, negatively affecting their physical and mental health (Ahorsu et al., 2020; Caputo & Reichert, 2020; Cullen et al., 2020; Mertens et al., 2020; Asmundson & Taylor, 2020).

However, during the pandemic, the various types of UGS were places where the residents sought relief and comfort (Ugolini et al., 2020), though the visitation patterns changed in time and strongly depended on local policies (Volenec et al. 2021). During the initial stage of the pandemic, the overall mobility significantly decreased (Devaraj & Patel 2021) as people were staying in isolation or quarantine (Mattioli et al., 2020). During this period the possibility of recreational activities and visits to UGS was largely limited. In Poland a strict lockdown was temporarily in April 2020, which limited people's outdoor activities, allowing only basic errands and depriving residents from entry to UGS. During this period, to discourage the public from gathering and spreading COVID-19, the authorities forbade entry to parks and urban forests. However, massive social disapproval of the inability to find comfort in nature during isolation forced the authorities to bow under the public pressure and reinstate the entry to UGS, which proved the importance of UGS and their high social support in Poland.

The need for access to UGS and contact with nature was amplified by the COVID-19 pandemics and the negative impacts of UGS access deprivation (Day, 2020; Heo et al., 2020; Lopez et al., 2021; Kleinschroth & Kowarik, 2020; Ahmadpoor & Shihab, 2021; Erdönmez & Atmiş, 2021; Lu et al., 2021; Venter et al., 2020). Visits to green spaces and contact with nature can effectively mitigate the harmful health effects of severe stressful life events (Berdejo-Espinola et al., 2021), including those resulting from confinement (White et al., 2013; Alcock et al., 2014; White et al., 2019; Cameron et al., 2020; Pouso et al., 2021). During the pandemics, people who had access to greenery kept better mental health (Dzhambov et al., 2021; Corley et al., 2021; Pouso et al., 2021) and had more social interactions (Maas et al., 2006; Mears et al., 2020; Xie et al., 2020). Also the sole presence view of vegetation outside the window had positive effect on residents well-being, but it could scarcely make up for the direct possibility of UGS visit (Ugolini et al., 2020).

The increased demand for UGS visits is however combined with increased anxiety related to maintaining a safe distance during recreational activities. Even outside of a pandemic, fear can be a limiting factor for UGS visits (Madge, 1997). In general, the perception of safety in UGS is linked to the assault anxiety, e.g. densely vegetated sites were described as less safe and more threatening (Baran et al., 2018). Also, neighbourhoods with a higher urban tree cover were perceived to be safer than those with a lower tree cover (Mouratidis, 2019). The COVID-19 outbreak contributed mainly to anxiety connected with the spread of the disease, hence even a minor crowding in UGS became a barrier preventing people from recreational activities (Jorgensen et al., 2002). Therefore, the pandemics evoked the need for UGS adaptation to ensure safety and triggered solutions that can enable comfortable rest and mental regeneration in UGS (da Schio et al., 2021). Historically, as a response to virus outbreaks, the alterations in UGS, such as creating wider boulevards, opening new built tree-lined streets or creating new parks, have already been made, which was the case in response to the cholera outbreak in the 19th century (Martínez & Short, 2021). Therefore, the outbreak of COVID-19 may have a long-term impact on UGS design. As much as the changes in visitation to UGS and the changes in peoples' attitudes towards COVID have been deeply explored (e.g. Lopez et al., 2021; da Schio et al. 2021), much less is known about the alterations that need to be implemented in UGS. Such adaptations must not only gain a social appreciation but also fulfil the residents' need for safety while ensuring the possibility of recreational activities. Such knowledge is of critical importance in UGS as areas where social expectations are the main drivers of management and urban planning decisions (Gobster & Chenoweth, 1989).

In this study, we investigate the preferences of city residents towards the alterations in the urban green spaces design which should take place to ensure health and safety in the post-pandemic environment. The study aimed to answer the following questions 1) What are the public preferences towards UGS types and their features ensuring safe and comfortable

recreation in a post-covid environment? 2) How are peoples' personal characteristics linked to the preferences towards changes in UGS 3) What are the factors necessary for maintaining social distance and recreational activities in UGS? The overarching goal of the study was to specify what type of landscape design is desirable in UGS and will enable the formulation of recommendations for UGS alterations that will address the modern post-covid challenges while keeping the resident's preferences in mind.

2. MATERIALS AND METHODS

2.1 Study area

We performed this study in Poland's capital city, Warsaw (52°13′5 6″N 21°00′30″E), which covers an area of 517.2 km^2 and is inhabited by nearly 2 million citizens (CSO, 2020). Overall, the city is characterized by a high UGS percentage, exceeding 50% of the city area, though unevenly distributed across the city and of varying maintenance intensity (Sikorska et al., 2021). Warsaw UGS consist of those formally designated, such as urban parks and forests, accounting for approximately 20%, complemented by agricultural areas, roadside vegetation or post-industrial sites (Sikorska et al., 2021). The deficiency of UGS is strongly visible in the city centre resulting in disparities in access to greenery among the citizens, particularly in terms of areas easily accessible by foot (Sikorska et al., 2020b).

2.2. Assessment of post-covid transformations of UGS

2.2.1. Preferences toward changes in UGS

We performed an online survey to identify the preferences of the residents of Warsaw towards the UGS and their post-covid transformation. The survey was limited to the city inhabitants, but also those not formally registered, but residing in the city. To cover various city's inhabitants, we distributed online questionnaires within social networks, such as official social media profiles devoted to greenery, which are typically followed by city's inhabitants,

and asked to forward the survey to other networks (snowballing approach). The pilot survey among students was used to test the questionnaire and eliminate potential inconsistencies. We distributed the survey in January 2021 during the lockdown in Poland. We checked whether the given respondent gave the same scores for various photomontages to verify for "clinking" without reflection. The scores assigned by the given respondent differed among photomontages, therefore we treated it as a signal that respondents were able to differentiate photomontages. The survey was performed using Google forms. It was fully anonymous and was in line with the ethical principles of market research and public opinion as defined in the International Code of Market and Social Research, which was developed jointly by the European Association of Public Opinion and Market Researchers, the European Society for Opinion and Marketing Research (ESOMAR), and the International Chamber of Commerce (ICC). In total 179 interviewees responded to the survey. The demographic profile (Appendix 1) of the questionnaire (n = 179) indicates a dominance of females (73.7%) over males. Participants were drawn from the younger age groups below 30 years old (62.5%), which is typical for internet surveys. They also represented wide range of educational backgrounds. There was a comparable group of participants who indicated environment-related education or employment (n = 68); to other users (n = 85).

The survey consisted of 5 main parts: 1) respondents' characteristics, 2) questions aimed to identify the anxiety level towards COVID-19 and recreational behaviour in UGS, 3) assessment of preferred UGS for comfortable rest and recreation based on photomontages 4) questions referring to different UGS features which were important for respondents in previously assessed images 5) questions referred to preferred UGS adaptations.

1) *basic personal information aimed to identify the respondent's background*

The interviewees were requested to provide personal data: age, gender, place of residence (type of the building they are inhabiting, number of people in the household and also number of city

inhabitants, for those not formally registered in Warsaw), education level, ecological awareness (ecology-oriented education, eg. biology, agriculture, landscape architecture studies), and employment status.

2) *identification of the anxiety towards COVID-19 and recreational behaviour in UGS*

We asked the respondents if they were afraid of infectious diseases in general and whether many people in the neighbourhood of their recreational activities bother them. They were also to answer if they avoided crowding during the pandemic and if they would avoid them afterwards to identify their overall attitude and behavioural patterns. The questions also included visits to places with a high share of natural greenery and whether they like to undertake recreational activities there as a measure of their activity and preference for spending time in UGS. All questions were to be answered on a 1-7 Likert scale. Detailed questions asked are presented in table ~~2~~1.

3) *assessment of preferred UGS for comfortable rest and recreation based on photomontages*

We assessed the preferences of the residents towards UGS based on the photographs which were digitally manipulated to represent various UGS types and settings. We identified what types of UGS people feel most comfortable in and how the crowding in different settings would be perceived, contributing to the overall anxiety of the respondents. Therefore, the various sceneries in the images were digital photographs taken in locations representing nine different green spaces most typical for the cityscape, i.e. greenery of an urban street, suburban street, greenery associated with residential-area, extensive lawns in urban park, forested urban park, informal greenspace with herbaceous vegetation, forested informal greenspace, dense urban broadleaved forest, loose urban coniferous forest (Fig. 1). We manipulated the sceneries by adding various levels of crowding on a walking path or nearby – no users, medium crowding (2-3 people present on the path) and crowded (more than 4-5 people), which might act as a barrier preventing the public from entry and evoking anxiety. In each of the sceneries we

inserted the silhouettes of people in a different way to avoid repeating the same setting and to mimic natural situations encouraging the respondents to complete the survey (not giving them the feeling of seeing the same situation again. All images of the sceneries were taken during the vegetation season 2019 in conditions of full vegetation development and full sunlight with a camera equipped with ⌀50mm lens at 1.7 m height to represent a comparable viewing angle of the observer. We presented the respondents with 27 images in total (Fig. 1) and requested them to assess each photograph on a 1-7 scale, where 1 referred to them not wanting to spend time in a given location while 7 referred to high willingness for recreation in a given location. The images were presented in random order.

4) *questions referring to different UGS features which were important for respondents in previously assessed images*

After having performed the image assessment, the interviewees were asked about factors they took most into account when performing the assessment, which they found to be connected to the recreation comfort, to verify whether their declared preferences differ from the choices they made in the image's). Respondents answered on a 1-7 scale, with 1 referring to the high influence of the given factor on the scoring and 7 for low influence.

5) *questions referred to preferred UGS adaptations*

This part consisted of 13 questions regarding the overall need for changing UGS to adapt to COVID-19 and examples of alterations in design or policy which could improve the safety and well-being of residents. The questions regarded creating various enclosures for people, enhancing social distancing, quality and number of paths, but also the overall availability of green spaces (whether the residents would indicate at the need of more greenery but closer to their place of residence) but also policies, such as entry limits or adaptations devoted only to specific vulnerable social groups.

Fig. 1. A series of photomontages used for the assessment of recreational preferences in varying settings and to a various extent crowded (A. suburban street, C. urban street, B. residential-area green space, D. urban park with extensive lawn, E. forested urban park, F. informal greenspace with herbs, G. forested informal greenspace, H. dense urban broadleaves forest, I. not dense urban coniferous forest).

2.3. Statistical Analysis

We analysed the scorings of both images, as well as the answers to questions regarding residents' attitudes towards UGS and preferable changes using ANOVA with Tukey's Test, at $p<0.05$. The mean values were analysed for the identification of landscape settings most preferable by the public and those where the respondents feel most comfortable concerning the possibility of maintaining social distance. We further analysed how the preferred direction of changes in UGS is associated with an individual's personal characteristics, such as gender, age, type of work etc., but also personal preferences towards UGS usage and those related to maintaining social distance. Those features were retrieved from the questionnaire answers related to anxiety levels and behavioural patterns and are presented in table~~s~~ 1~~ and 2~~.

To uncover the link between the personal features and the preferred changes in UGS design we used a series of linear regression models. In particular, we regressed each of the twelve directions of changes in UGS using the same set of individuals' features (personal characteristics and attitude towards UGS). We applied the linear regression models because our dependent variables were collected using the Likert scale ranging from 1 (strongly disapprove of the given direction of changes) to 7 (strongly approve of the given direction of changes) and therefore could be treated as quasi-continuous (Jamieson, 2004; Liddell & Kruschke, 2018).

The individual's characteristics, which might affect the respondents' choices, were expressed by thirteen binary independent variables such as gender, age, type of work etc., (Table 1 and Appendix 1). The COVID-19 - related individual's fears were included as six independent variables, each of them ranging from 1 (strongly disagree) to 7 (strongly agree).

Finally, the scorings of preferences towards greenery design were included as seven independent variables ranging from 1 (not important) to 7 (very important) (Table ~~2~~1).

We used the stepwise method to fit each regression model and applied Cook's Distance to identify and eliminate outliers. Then, we checked residuals normality and heteroscedasticity using Jarque-Bera and Breusch-Pagan tests, respectively (Baltagi, 2002). In those regression models in which residuals suffer from heteroscedasticity, we used the heteroscedasticity-consistent covariance matrix (Kleiber & Zeileis, 2008). The adjusted coefficient of determination (adj R2) was used to measure the goodness-of-fit of the regression models.

Table ~~2~~1. ~~Respondents~~ Respondents' individual characteristics and preferences towards changes in UGS used as dependent variables in the regression, values retrieved from the questionnaire, answers in a 1-7 scale

	Independent variable code	**Variable type**	**Question in the survey**
1	~~covid~~Covid_worry	Questions related to worries evoked by COVID-19 and behavioral pattern in UGS, 1-strongly disagree, 7 strongly agree	Do you consider yourself a person anxious about airborne spread diseases?
2	People_like		Are you bothered by other visitors in the place of rest/recreation?
3	Covid avoidance_ now		Do you avoid crowded places during pandemia?
4	Covid avoidance after		Are you going to avoid crowded places after pandemia?
5	Nature_go		Do you visit places with a lot of greenery?
6	Nature_like		Do you like to relax in places with a lot of greenery?
7	P_Green_many	Answers to questions regarding the importance of given factors in providing comfortable rest and recreation in the assessment of the photomontages (self-reported), 1 – low importance of a factor, 7 – high importance	Share of cultivated greenery
8	P_Green_wild		Share of wild greenery
9	P_Green_density		Vegetation density
10	P_Track_many_people		Number of people on the path
11	P_Track_free		Possibility of freely straying off the path
12	P_Building		Presence of buildings
13	P_View_wide		Extent of the view
	Dependent variable	**Variable type**	**Question in the survey**
1	Greenspace_change	Answers to questions regarding preferred changes in UGS to provide comfortable recreation and rest in post-covid environment, 1–7 scale, 1 – disapprove, 7 – high approval	Should the UGS change after COVID-19 pandemia to accommodate the risk of future airborne diseases?
2	Greenspace_place_more		Should there be more places in UGS allowing social distancing (eg. rest for 1-3 people)
3	Greenspace_veg		Should there me more vegetation in UGS?
4	Greenspace_separate_sen		Should there be separate resting places for most vulnerable social groups, eg. the elderly?
5	Greenspce_limits		Should there be entry limits introduced to UGS?
6	Greenspace_small_site		Do you support separating small enclosures in UGS available for small groups of people (1-3 people)?
7	Greenspace_track_wide		Should the walking paths be wider?
8	Greenspace_more_minor		Should there be more UGS of smaller size, rather than bigger UGS but less?
9	Greenspace_closer		Should there be more small green spaces close to places of residence (in housing estates)?
10	Greenspace_trampling		Should there be more paved paths?
11	Greenspace_more_tracks		Should there be more paths in UGS?
12	Greenspace_minor		Should the newly created places for rest be smaller
13	Greenspace_distance		Should the places for recreation be more spatially distant?

3. RESULTS

3.1 Assessment of preferred UGS for comfortable rest and recreation based on photomontages

The results of our study show that the residents comparably assess recreation comfort in different UGS types, based on average scorings of presented images. Only sceneries with the highest share of human-made structures i.e. urban streets and multi-family residential areas were significantly less attractive (Fig. 2). Surprisingly the suburban areas were comparably assessed to natural green spaces. There was also no significant difference between natural ecosystems, such as deciduous or pine forests compared to cultivated vegetation of parks or informal green spaces (Fig. 2). However, when taking into account the crowding, the differences in preferences were more visible and the crowding ins the factor significantly reducing the recreational comfort in most of the examined UGS. The appearance of people on the track always resulted in significantly lower scoring. For suburban areas and informal forested greenery there was a significant decrease of comfort between empty track, medium and high amount of people, while in the case of urban street and informal herbaceous vegetation only the high number of people resulted in a decrease of scoring, while empty track and little crowded were similarly attractive for recreation. We found that the need to maintain social distance to be most noticeable in those UGS types where any crowding resulted in decreased of scoring, ie: forests, informal green spaces and suburban greenery, where emergence of any number of people decreased the scoring, independently if this was medium or high crowding.

In parks, urban streets, and residential areas, when more users appear, subsequent individuals no longer cause changes in the scenery assessment. Distancing measures are therefore needed primarily in the former group of UGS.

3.2. Factors important for comfortable recreation in UGS, selected features vs. declared

Based on the responses to the questions regarding factors the respondents found to be most important when choosing sceneries ensuring recreation comfort, the most important were the overall amount of greenery, both cultivated as wild vegetation and its overall volume, followed by the visibility of buildings (which negatively affected the scoring but was important in the assessment). Other factors, such as the possibility of freely straying off the path or the number of people on the path were also taken into account but were significantly less important for the respondents, according to their self-declared assessment (Fig. 3).

The respondents declared to little consider whether the path was crowded or not when evaluating the UGS provisioning of comfortable rest and recreation (Fig 3.). However, we found a discrepancy between the preferred images and stated preferences in terms of how the presence of people affects the recreational comfort – the respondents always assessed the locations with no or little people on the track as most preferred but claimed that that this factor was not important in their assessment (Fig. 2 and 3). In the case of all sceneries, people chose more willingly those bereft of other visitors rather than the crowded ones. This differentiation suggests that the actual choices and stated preferences might largely differ and despite declaring low anxiety towards COVID-19 the residents might actively avoid social interactions. Residents' fears related to the spread of COVID-19 are visible in their preferences toward UGS.

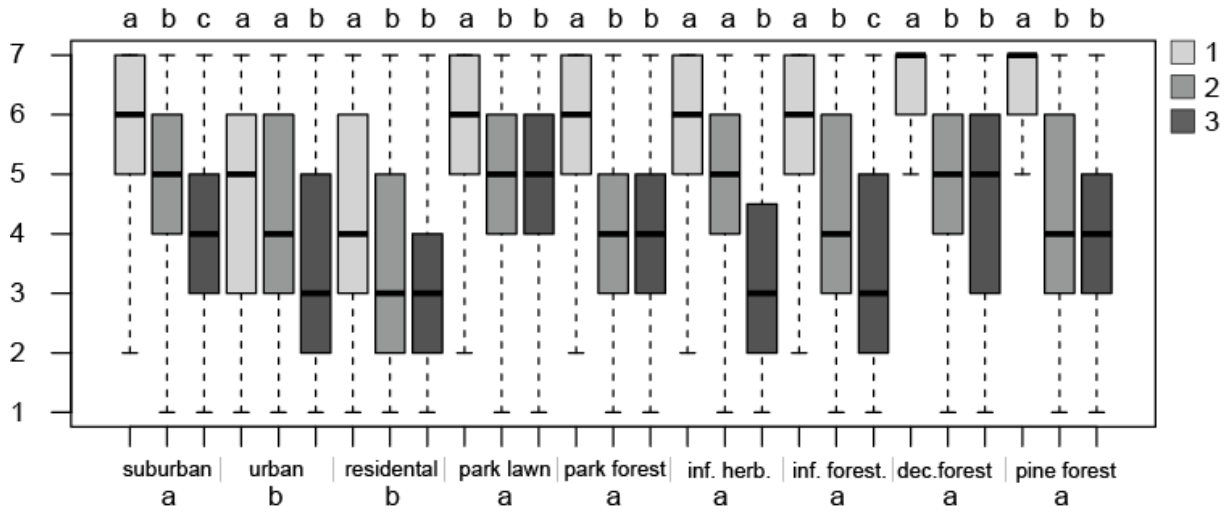

Fig. 2. Differences in the respondents perceived comfort in various types of UGS based on photomontages scorings in a 1-7 scale; 1 – low recreation comfort, 7 – high recreation comfort; scenery types: suburban - suburban street, urban - urban street, residential – residential area greenery, park lawn - urban park with extensive lawn, park forest - forested urban park, inf.herb – informal greenspace with herbs, inf.forest – forested informal greenspace, dec.forest– dense urban deciduous forest, pine forest – loose urban coniferous forest; letters a-c indicate at statistically homogenous groups in ANOVA with Tukey's test at $p<0.05$.

3.2.

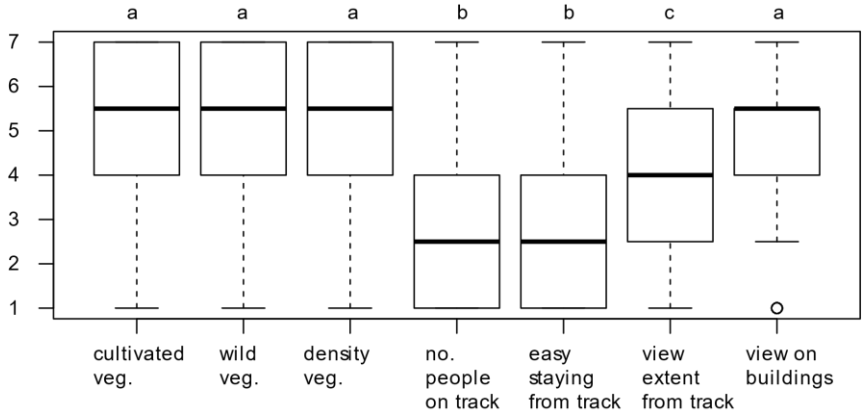

Fig. 3. Factors reported by the respondents to be taken most into account in the scorings of photomontages with respect to providing comfort of recreation by UGS in a 1-7 scale, 1 indicating no impact on the assessment, 7 highly influencing the assessment. Letters a, b, c represents homogenous groups in ANOVA with Tukey's test at $p<0.05$. Factors description as in Fig. 3.

3.3 Preferred adaptations in UGS vs personal characteristics

Our results indicate that the majority of the respondents (61%) opt for changes in UGS after the COVID-19 outbreak The preferred changes of UGS strongly depend on the overall attitude towards COVID-19 and are also influenced by behavioural patterns and UGS usage. The most preferred changes were four out of twelve postulates: more vegetation, more paved pathways, more sites separated for 1-3 persons in the park, but fewer pathways in general in the green public spaces.

We confirmed a key role of UGS during the pandemic and the need for their adaptations, especially in terms of introducing more vegetation, and improving infrastructure which would enhance accessibility and allow maintaining social distance. The respondents indicated the need for increasing the overall share of vegetated surfaces in the city and adapting the UGS towards the possibility of maintaining social distance by introducing various types of enclosures or the quality and the quantity of paths (Fig. 4). People indicated the importance of UGS close to their place of residence, even if they are of small size, in the case of introducing new UGS more areas of smaller size were preferred over bigger objects but less abundant. Also, the presence and introduction of new infrastructure were important as the respondents highlighted the need for more paved surfaces in UGS, which would facilitate the possibility of maintaining social distance. The least important (Figure 4, Table. ~~3~~2) in the respondent's opinion was the adaptation of UGS to meet the needs of selected groups of the population, they did not highlight the need for the creation of separate resting areas for seniors. Any repressive actions, by distancing in space, isolating seniors or introducing entry limits on the number of people did not meet social approval (freedom and unlimited leisure are the most important values). Overall few respondents declared the support for any type of isolation in UGS, but women support it the least and people who expect dense greenery for the comfort of rest (people expect the most freedom in using greenery). The lowest level of acceptance for entry limits in

UGS is visible, especially among residents of large cities and people intending to avoid crowded places after the pandemic (Table 2).

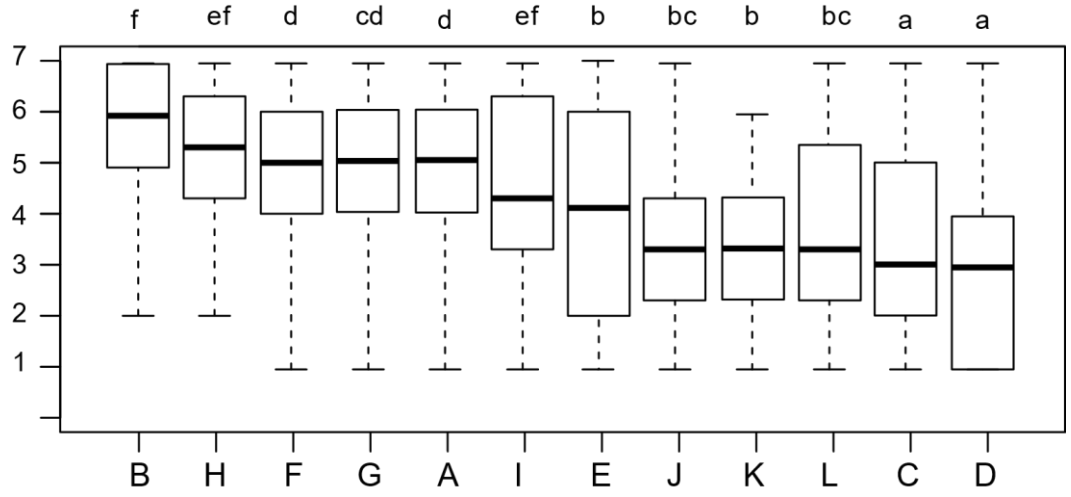

Fig. 4. Average preference towards UGS adaptations (A-L) to provide recreation comfort based on questionnaire, preferences towards given adaptation shown in ~~a~~ descending order of preference towards given adaptation, 7 – high approval, 1 – disapproval; questions regarding preferences in the survey as in table ~~2~~1: B. more vegetation, H. more small UGS close to the place of residence (housing estates) rather than bigger UGS but less? F. wider paths, G. more UGS of small size, rather than bigger UGS but less, A. more places allowing social distancing (eg. rest for 1-3 people), I. more paved pathways, E. separating small enclosures in UGS available for small groups of people (1-3 people), J. more paths, K. newly created places for rest smaller L. places for recreation more spatially distant, C. separate resting places for vulnerable groups e.g. seniors, D. entry limits introduced a-f – homogeneous groups at $p<0.05$ in ANOVA with Tukey's post hoc test;

Table ~~3~~2. Regression model results for personal characteristics related to their preferences towards changes in UGS. The codes for personal individual characteristics as in Tab. 1 and ~~2~~Appendix 1, preferred changes as dependent variables as in Tab. ~~2~~1.

	Greenspace_small_site		Greenspace G_minor		Greenspace _more_min		Greenspace_more_tracks		Greenspace _track_wide		Greenspace _distance		Greenspace _separate_sen		Greenspace _limits		Greenspace _place_more		Greenspace _veg		Greenspace _closer		Greenspace _trampling	
	coeff	p	coeff	p	coeff	p	coeff	p	coeff	p	coeff	p	coeff	p	coeff	p	coeff	p	coeff	p	coeff	p	coeff	p
(Intercept)	5.27	0.00	5.57	0.00	5.36	0.00	4.98	0.00	5.52	0.00	6.31	0.00	6.51	0.00	4.66	0.00	2.19	0.00	3.32	0.00	3.21	0.00	4.66	0.00
Personal characteristics					.	.																		
Sex	.	.	.	.			.	.	.	.	.	.	.	.	.	.	0.82	0.01	.	.	.	.	.	.
Age					.	.																		
31-40	.	.	-0.82	0.04	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
41-50	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-0.99	0.02	.	.	0.76	0.04	.	.
>50	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Work					.	.																		
student	.	.	-1.31	0.03	.	.	.	.	.	.	.	.	-1.26	0.01	.	.	.	.	.	.	.	.	.	.
unemployment	-2.99	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-1.52	0.04	.	.	.	.	.	.
worker	-0.82	0.01	.	.			.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
City					.	.																		
1.000-100,000	.	.	.	.	0.81	0.01	.	.	.	.	.	.	-0.69	0.02	.	.	.	.	.	.	.	.	.	.
> 100,000	.	.	.	.			.	.	.	.	.	.	.	.	-0.72	0.00	.	.	-0.56	0.03	.	.	.	.
House type					.	.																		
Multifamily house	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
No other people in a house	.	.	-0.22	0.03			-0.21	0.03	.	.	.	.	.	.	.	.	.	.	.	.	-0.19	0.05	.	.
Users (no experts)	.	.	.	.	-0.52	0.05	.	.	.	.	0.38	0.04	.	.	0.81	0.00	.	.	.	.	.	.	-0.68	0.00
Covid worries and behaviour																								
Covid_worry	-0.2	0.03	-0.17	0.03	-0.28	0.00	.	.	-0.17	0.03			-0.18	0.01	.	.	.	.	.	.	-0.26	0.00	-0.13	0.05
People_like	-0.2	0.02	.	.	.	.	.	.	-0.18	0.03	-0.13	0.04	.	.	.	.	.	.	.	.	.	.	.	.
Covid avoidance_now	.	.	.	.	0.23	0.01	.	.	.	.	.	.	0.14	0.04	.	.	.	.	.	.	0.2	0.02	.	.
Covid avoidance_after	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-0.31	0.00	.	.	.	.
Nature_go	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Nature_like	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.	0.32	0.00	.	.	.	.
Factors important for comfort in UGS																								
P_Green_many	.	.	.	.	.	.	.	.	.	.	.	.	0.18	0.03	.	.	.	.	.	.	.	.	.	.
P_Green_wild	.	.	.	.	.	.	.	.	.	.	0.14	0.04	.	.	.	.	0.32	0.00	.	.	.	.	0.19	0.02
P_Green_density	0.22	0.05	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
P_Track_many_people	.	.	.	.	.	.	.	.	0.21	0.05	.	.	.	.	.	.	.	.	.	.	.	.	.	.
P_Track_free	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
P_Building	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.23	0.03	.	.	.	.
P_View_wide	.	.	.	.	.	.	.	.	.	.	-0.17	0.01	-0.26	0.00	.	.	.	.	.	.	-0.21	0.03	.	.
Breusch-Pagan test	0.2658		0.2016		0.27		0.2859		0.1597		0.9653		0.08		0.06		0.00		0.01		0.4946		0.4101	
Jarque-Bera test for normality	0.0425		0.086		0.0614		0.2982		0.0229		0.1216		0.03		0.03		0.04		0.00		0.0004		0.0162	
R-squared	0.1095		0.07724		0.09472		0.0687		0.1031		0.02095		0.13		0.15		0.10		0.08		0.1148		0.1107	
N	174		179		175		177		172		177		179		178		178		179		176		174	

The preferences towards adaptations were however strongly dependent on socioecological background and personal characteristics. The fear and anxiety related to the spread of COVID-19 and other airborne diseases are manifested in various residents' reactions, which we define based on the results of the regression results calculated between people's characteristics and their endorsement of proposed changes in UGS (Table ~~3~~2). For example, the need to increase the width of paths in UGS was supported mainly by a group of respondents who have the highest rates of COVID-19 fear and those were rather ordinary users rather than those with an ecological background. On the other hand the need to improve infrastructure, such as paths even among respondents originating from smaller cities the city of 1000-100,000, and those who declared avoidance of crowded places introducing wide paths did not seem necessary.

We singled out two basic approaches towards UGS adaptation in relation to the respondents attitude, behavior and preferences. The first reaction is by a group of residents revealing the overall worry over the consequences of the pandemic, while the second is the avoidance of other people. This refers to people avoiding contact and maintaining distance, whose attitude towards COVID-19 is manifested in their actions. While the first group of people only declares their fears, the latter's group attitude is expressed in their active choices. The two groups declare adverse preferences. In the case of those who only reveal their worry towards COVID-19 we found a tendency of undervaluing actions for adaptations in UGS. It is revealed in always negative correlations with the preferences towards proposed actions (Table ~~3~~2). Those who declared fears towards COVID-19 had lower approval of implementation of given UGS alterations. This included especially designing small recreational spaces hosting small groups of people, introducing more and wider paths or creating new UGS. The people who put their worries into action by avoiding social interactions in UGS always support interventions such as introducing more greenery close to their place of residence, widening the paths as well

as creating more new greenery of small size, rather than greenery of big size but less in number and the higher the rate of avoidance the higher their approval. We also singled out a group of people who indicate that contact with nature is important for them and they declare more need for wilderness in cities. This shows a preference for increasing the overall share of vegetation in UGS. It would also endorse visitor limits and separate the more vulnerable groups, which are postulates unsupported by other groups of respondents. At the same time, it is showing no preference for changes in UGS infrastructure which could facilitate maintaining social distance.

The results of the regression (Table ~~3~~2) and mean values of the scorings of preferred adaptations in UGS (Fig. 4) also allow us to uncover what personal features were most important in the support of a given change in UGS. The alteration that received the highest scoring was the overall increase of greenery (Fig. 4). However, it was little linked to any particular residents' feature, apart from being favoured by those respondents who declare to be nature-seeking. It was also less supported by the residents of bigger cities. As far as the proximity of UGS and their accessibility is concerned, it was of little importance to those fearing COVID-19 but not actively avoiding encounters with people. On the contrary, those avoiding interactions with others opted for cultivated greenery rather than wild and were seeking easy access to UGS close to their place of residence. Those relations are the strongest in big cities among middle-aged and older residents. When it comes to the presence of infrastructure, such as paths, that could facilitate maintaining social distance, the preferences vary for the residents. In terms of the number, we noted the preference to create more paths only for the respondents with ecological backgrounds and preferring wild vegetation. People who were expressing fear of the airborne spread of diseases did not reveal their need towards creating more pathways in the future, while those afraid of COVID-19 and actively distancing themselves from others, followed by experts, would accept the current state of UGS but would strongly support widening the paths as alterations allowing them to maintain the distance from

other users. Surprisingly, those fearing COVID-19, but not declaring to take preventive actions in the future, negatively assess widening the paths and are most conservative in the matter. In terms of the surface of the paths, the paved pathways are only indicated by people from smaller cities and experts. Creating new UGS but of smaller size was unsupported by those fearing COVID-19, while it was preferred by those who actively distanced themselves from others and middle-aged groups of respondents.

Shaping UGS in a way to create resting places hosting a small number of people was unsupported by those fearing COVID-19 but not revealing behaviours that would distance them from others and this group indicated the need to provide contact with others in UGS in the future. Those who opt for separating people in UGS also prefer dense greenery. Similarly, separated enclosures in UGS hosting a small number of people were negatively assessed by those fearing COVID-19 but not aiming to change their social behaviour in the future. It was also noted for the group indicated a high need for social interactions. We observed a similar pattern in the case of creating new UGS of smaller size, which could facilitate maintaining social distance. This was unsupported by those fearing COVID-19 but this change in UGS was positively perceived by those preferring wild vegetation. Fears towards COVID-19, whether passive or active, were not linked to favouring more distant resting places in UGS, and the only connection we found was the negative perception of the possibility to rest in UGS in more distant locations by those inhabiting households with more people. Segregating the residents by designing recreational spots for selected groups, such as the elderly, found no support neither in those fearing COVID-19, and it was negatively perceived by the elderly themselves, followed by the unemployed and men. The approval for this alteration was visible for women and those favouring wild vegetation. Similarly, introducing entry limits was not linked to the fears of COVID-19, but it was supported by those who actively avoid COVID-19. This solution was

also supported by people from bigger cities, those seeking nature and being not in favour of buildings within a view.

4. Discussion

The ongoing discussion over the actions that cities need to take to address the challenges brought about by COVID-19 mostly focuses on measures needed to avoid undesirable social effects in subsequent pandemics (McNeely, 2021). Urban green spaces and their positive impact on society are an important component of the proposed actions (Megahed & Ghoneim, 2020; Dobson et al., 2021; McNeely, 2021). Policymakers, planners and practitioners are prompted to plan cities' green infrastructure with more consideration of its role in supporting the residents' mental health and well-being, significantly impaired during the pandemic (Barton et al. 2020; Kleinschroth & Kowarik, 2020; Ugolini et al., 2020; Dobson et al., 2021). The pre-pandemic efforts to improve the availability and accessibility of UGS (Kleinschroth & Kowarik, 2020; Sikorska et al., 2020a) were supported by the subsequent results emerging from this study, which indicate the need to increase the number of green areas as well as to adapt them to face the challenges of airborne spread diseases and enable maintaining safe recreation.

The responses of participants of our study revealed various behavioural patterns of city residents in a post-covid environment and showed how their anxiety about airborne diseases is in turn linked to their opinions towards UGS adaptations. We identified behavioural patterns towards UGS visits and their adaptation to COVID-19. Some people were mostly driven by the fear of COVID-19 and give up further travel while visiting green spaces closer to their homes, which in turn highlighted the importance of UGS, even of small size, close to the place of residence (Ugolini et al., 2020; Fagerholm et al., 2021; Liu & Wang, 2021; Table ~~3~~2). Another group of people who frequently visited UGS before the pandemic undertook further

trips on foot, bike and by car to more distant places, even outside the city (Ugolini et al., 2020; Fagerholm et al., 2021), even though before the pandemic, they chose the nearby areas and were not bothered by crowds (Fagerholm et al., 2021). This group does not reveal a greater than average fear of COVID-19, does not opt for alterations in UGS such as wide paths and does not indicate the importance of UGS being located nearby (Table ~~3~~2). What is important for them is wild vegetation in UGS which allows having an impression of more contact with nature (Wolsko et al., 2019; Fagerholm et al., 2021; Table ~~3~~2). These two approaches to recreation are likely to persist after the pandemic, which supports the need to increase urban greenspace diversity (Ugolini et al., 2020). Our research reveals contradictory expectations towards changes in UGS of the public. While some express that their comfort is significantly influenced by wild vegetation and others point to ordered cultivated, but dense, vegetation and the wide extent of the view (Fig. 3). To meet those expectations, it is necessary to introduce diversification of forms, leisure activities and recreational options within UGS, with both cultivated vegetation as well as introducing areas bereft of maintenance. The preferences towards the management of vegetation and whether it should be cultivated or wild have been long investigated, and the views vary even within the studies performed so far in Warsaw. In general Warsaw citizens show preference toward ordered nature, however reveals increasing acceptance for new forms of greenery such as green tram tracks (Sikorski et al., 2018), replacing the existing lawns with energy crops (Sikorska et al., 2020b) or intended abandonment of cultivation in UGS and allowing nature to “take over” (Sikorski et al., 2021). A variety of new forms of greenery and recreational facilities can allow meet the expectations of society while at the same time preparing the cities for biological and environmental threats. Also, in the face of the increasing popularity of the environmental justice perspective, indicating that all citizens, particularly the most vulnerable groups, should be able to equally benefit from nature and the ecosystem services it provides (Łaszkiewicz & Sikorska, 2020) the future design and planning

decisions need to take into account the need to increase the spatial extent of large green spaces adapted to escape into nature, as well as smaller UGS such as pocket parks and gardens accessible within a short walk from their home (Ugolini et al., 2020).

We found no support for taking additional measures for the selected groups of citizens, or implementing restrictions, limiting the number of people in the park and isolating seniors are not indicated as the preferable option (Table ~~3~~2). This, even more, indicates fair access to urban nature (Derks et al., 2020; Lennon, 2020; Venter et al., 2020; Scott, 2021). Behavioural changes during the pandemic were related to the dissonance caused by the willingness to visit green areas and, at the same time, the fear of becoming infected when meeting other people (Ugolini et al., 2020). More than half of the respondents reduced the number of visits to green spaces after the COVID-19 outbreak (Heo et al., 2021; Wilmers et al., 2021). For those people, resuming visits to UGS were most important (Ugolini et al., 2020), despite the fear of COVID-19 transmission might impact their decision to visit UGS. Interestingly, people who visited UGS in crowded places did not report feeling uncomfortable (Samuelsson et al., 2021).

Our research indicates that people fearing COVID-19 are the greatest supporters of change in green public spaces (Table ~~3~~2). While planning and design specialists are absent from the discourse on current and post-COVID-19 action strategies to implement changes in UGS, even though previous pandemics have historically revealed their essential role. There is a need to better design creative and appropriate protocols in collaboration with health organizations (Allam & Jones, 2020) to meet the emerging needs of city residents, particularly in reference to various behavioral strategies (Wajchman-Świtalska et. al 2022).

5. Limitations of the study

We carried out the research during the strict lockdown when the mobility of the residents was to a large extent limited. It must be taken into account that the identified declared choices and those which are applied in practice might in fact change as the pandemic is slowly subsiding. The persistence of these expectations is mostly consolidated by fear and anxiety. It was pointed out that there are groups of respondents classified as fearing covid, but not putting those fears into practice. Those residents contest the changes, but with a longer-lasting pandemic, or the next wave of the pandemic, they may get used to the situation and behave less conservatively. The survey was done in an urban sample of internet users, therefore the sample may not be representative of the entire population, but it certainly shows trends specific to young and middle-aged adults. Also the photomanipulations used to mimic the natural settings with various layouts of people in the scenery, which might have affected the results. As any other visual assessment methods the results should be interpreted with caution as they would only partially reflect real situations.

6. CONCLUSIONS

The COVID-19 outbreak has evoked the need for changes in UGS, however, the results also show that the pandemic does not introduce new directions in the planning of green areas, but it does modify the existing ones. The respondents opted for more vegetation and more UGS which can be of smaller size, improving the possibility to maintain social distance. They consider the social distancing to be of low importance, but when it comes to the choices of the photomontages it does appear as the most important factor for comfortable recreational activities in UGS. This indicates the necessity of actions aimed at creating opportunities for social distancing.

The need to maintain social distance is most noticeable in forests, informal green spaces and suburban greenery and this is where distancing measures are needed primarily in the former group of ecosystems. In parks, urban streets, and residential areas, once more other users appear, subsequent individuals no longer cause changes in the scenery assessment. Our results, therefore, indicate the need to create more UGS that are more easily available, closer to the place of residents, which would facilitate higher comfort of users, where the medium number of visitors would be tolerated, not impeding the recreational comfort.

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