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Gardening can relieve human stress and boost nature connection during the COVID-19 pandemic

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ABSTRACT

The COVID-19 pandemic has severely disrupted social life. Gardens and yards have seemingly risen as a lifeline during the pandemic. Here, we investigated the relationship between people and gardening during the COVID-19 pandemic and what factors influenced the ability of people to garden. We examined survey responses ($n = 3,743$) from gardeners who reported how the pandemic had affected personal motivations to garden and their use of their gardens, alongside pandemic-related challenges, such as food access during the first wave of COVID-19 (May-Aug 2020). The results show that for the respondents, gardening was overwhelmingly important for nature connection, individual stress release, outdoor physical activity and food provision. The importance of food provision and economic security were also important for those facing greater hardships from the pandemic. While the literature on gardening has long shown the multiple benefits of gardening, we report on these benefits during a global pandemic. More research is needed to capture variations in public sentiment and practice – including those who do little gardening, have less access to land, and reside in low-income communities particularly in the global south. Nevertheless, we argue that gardening can be a public health strategy, readily accessible to boost societal resilience to disturbances.

1. Introduction

The global COVID-19 pandemic has disrupted society psychologically and socially (Saladino et al., 2020). As with historical pandemics, COVID-19 has accentuated health disparities and unequal access to greenspace among disadvantaged and marginalized populations (Abrams and Szefer, 2020; van Dorn et al., 2020). For instance, populations experiencing food insecurity and health vulnerabilities (Ranscombe, 2020), and those with limited access to quality greenspace for recreation and stress relief (Geary et al., 2021; Keenan, 2020), have been impacted greatly during this pandemic.

New and old social challenges under COVID-19 have heightened questions around the role, function and provision of greenspaces (Geary

et al., 2021; Wray et al., 2020), and the security of and access to food and produce (Lal, 2020; Pulighe and Lupia, 2020). Fresh produce, greenspace and connection to nature are fundamental to mental wellbeing and physical health (Russell et al., 2013). Disrupted food supply chains emptied supermarket shelves and often failed to meet the need of populations in cities and towns (Aday and Aday, 2020). Economic insecurity from job and income loss left those most food-insecure increasingly vulnerable and a looming mental health crisis (Blustein and Guarino, 2020). People's social contact and mobility has been restricted to varying degrees, with many being required to work and study from home (Bonaccorsi et al., 2020), with reduced access to grocery stores (Schanzenbach and Pitts, 2020) and limited social interactions (Block et al., 2020). Those most food insecure, such as low-income residents

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and families with children, were more vulnerable to empty store shelves or job loss during COVID-19 (Lal, 2020; Pulighe and Lupia, 2020). Neighborhoods lacking greenspace were also vulnerable to recreational disruptions compared to areas with greater access to greenspace (Wray et al., 2020). Reduction of social networks and social isolation during lock-downs disproportionately affected the health of elderly populations and those already with mental health disabilities (Lee, 2021; Schormans et al., 2021; Turner-Musa et al., 2020).

During this time of uncertainty and threats to human health, gardens (from large allotment gardens to smaller backyard and balcony planters) appear to have risen as something of a lifeline for people (Abe and Cheibub, 2021; Champ, 2020; Dillon, 2020; Marsh et al., 2021; Oreglia, 2020; Schoen et al., 2021). As infection rates spiked in nations across the world, so did people's online interest in gardening (Lin et al., 2021). Recent case studies and commercial media outlets have portrayed the health benefits that individuals sought and received from greenspaces (Samuelsson et al., 2020) and gardening during the pandemic (Champ, 2020; Mejia et al., 2020; Schauder and Turbet, 2020; Schoen et al., 2021). These accounts align with prior understanding of the social, health and therapeutic benefits of gardening, including relaxation, connection to nature, and education (Howarth et al., 2020; Kingsley et al., 2020; Soga et al., 2017). Gardening can facilitate stress reduction through interactions with natural elements, which bolster human health (Lin et al., 2018; Ossola et al., 2018a; Russell et al., 2013; Thompson, 2018). Gardening is also important for social connection and building social cohesion within communities (Alaimo et al., 2010; Kingsley et al., 2020; Kingsley and Townsend, 2006). Yet, these recent comments and case studies provide little quantitative, comparable data on the changes in the value of gardening and garden use as affected by an acute global disruption, such as the COVID-19 pandemic.

We lack an overview of how gardening provides multiple health and wellbeing benefits for populations during the COVID-19 pandemic, how gardening may assist individuals to overcome hardships, and what challenges people may face to garden for such benefits. Furthermore, it is unclear whether or not people's prior experience with gardening may have mediated the benefits and challenges that they experienced. The extent to which, and how, people garden during crises can work to clarify perceptions and values of gardening and diverse long-term benefits to inform greening initiatives, community food security and outdoor health interventions during 'ordinary' times.

This paper investigates the relationship between people and gardening in the early stages of the COVID-19 pandemic (June to August 2020), exploring what factors influenced people's ability to garden and their relationship to gardening over this time. To do so, we examined survey responses from gardeners who reported how the COVID-19 pandemic affected personal motivations to garden and use of their gardens, alongside pandemic-related challenges, such as food access. We posed three research questions, each underpinned by a specific hypothesis, to answer how the relationship between people and gardening might have changed during the early stage of the pandemic:

- **What do people value the most about gardening during the COVID-19 pandemic (Q1)?** We hypothesize that food provision and food access, therapeutic (stress relief), and economic benefits will be the most important reported benefits of gardening among the diversity of benefits provided by this practice (Barthel and Isendahl, 2013; Lal, 2020) (H1);
- **To what extent does people's previous gardening experience influence their responses to potential challenges to garden during the pandemic (Q2)?** We hypothesize that gardeners with longer experience (years) gardening will report fewer gardening-related challenges and less changes to their ongoing gardening activity (Barthel et al., 2010; Fazey et al., 2007) (H2); and
- **Do people value gardening more if they faced greater personal hardships during the COVID-19 pandemic (Q3)?** We hypothesize that increased self-reported COVID-related daily difficulties will

increase the perceived importance of gardens and time spent gardening than those with fewer difficulties to cope with these hardships (Lal, 2020; Shimpo et al., 2019) (H3)

Here we define gardening as an activity in which people grow, cultivate, and care for plants (flowers or vegetables) for non-commercial or commercial use in different types of systems (e.g., institutional, residential, guerilla) characterized by their various scales of production, primary functions and management and tenure arrangements (McClintock, 2014; Soga et al., 2017).

2. Methods

2.1. Data collection

We administered a survey on the impacts of the COVID-19 pandemic on gardening using the *Qualtrics* online platform (Appendix 1). We targeted developed countries that were facing simultaneous peaks in COVID-19 infection rates early in 2020 and thus government lockdown responses (Lin et al., 2021). Survey dissemination initially focused on the USA, Australia, and Germany where the authors are based, and snowballed through the use of social media networks and listservs (see below) to other countries including regions in different climates, seasons and socio-economic background. To increase participation the survey was translated in four languages prepared by native speakers (English, German, Spanish, Vietnamese). Though we did not aim to limit survey responses to different parts of the world, we acknowledge that our approach is limited in its extent to sufficiently cover all nations experiencing similar or extreme impacts from the pandemic due to the lack of networks in countries worldwide that would have supported the online survey distribution.

The survey consisted of a mix of multiple choice, 5-point Likert scale, and open-ended questions, all of which could be skipped by respondents (Appendix 1). In this paper, to address the three research questions stated above (Q1-3), we focus on the quantitative responses to five survey questions focused on: what respondents' value about gardening; how they have changed their gardening activity; and whether they have experienced hardships during the COVID-19 pandemic. We designed these questions with consideration of known benefits of gardening (e.g., connection to nature, knowing where food comes from, social connection) from the literature (Soga et al., 2017; Thompson, 2018), to specifically investigate how these benefits may have changed during the pandemic. Here, one of the research questions is based on a combination of two survey questions. Qualitative and open-ended responses are analyzed and reported on elsewhere (Marsh et al., 2021).

In addition to these questions, we asked respondents about their age, gender identity, education level, gardening experience, and the location of their gardening activity (see Appendix 1 for specific detail). The survey instrument was pilot-tested on gardeners and academics prior to distribution. All aspects of the research design, questions and recruitment were independently approved (blinded for review; Human Research Ethics Committee (Project ID: 3031) and Institutional Review Board (Project ID: 1602882-1)). Participants consented to a Plain Language Statement approved by these ethics committees prior to the start of the survey that informed them of the objective of the research (Appendix 2). To participate in the survey respondents had to be over the age of 18 years and individuals could opt out of the survey at any time. Prospective respondents were recruited online by using a variety of platforms, including specialized media and newsletters (e.g., Gardening Australia, German Ecological Society, Deutsche Gesellschaft für Gartenkunst und Landschaftskultur DGGL e. V., UK's Royal Horticultural Society, University of California Master Gardener Program), and targeted social-media groups (via Twitter, LinkedIn and Facebook), and targeted emails to gardeners' groups in each researcher's home country. *Qualtrics* was chosen for this study to increase participation as surveys could be completed on both a mobile device and desktop computer. Because we

only used an online platform, the sample is limited to respondents with internet access.

The survey was open for three months from June to August 2020, representing a large section of the growing season in the northern hemisphere and part of the growing season in the southern hemisphere, resulting in 3,743 responses that were >60 % complete. For this analysis, in order to make comparisons across all questions, we excluded respondents where there were no responses to all of the survey questions (above) and who stated “I do not currently garden, but I am interested” to the question “How long have you been gardening” to focus on those that specifically have been gardening during the early months of the COVID-19 pandemic. These inclusion criteria resulted in 1,449 responses for our analysis here (38.76 % response rate for all questions analyzed), representing respondents from 21 countries (Table 1; Appendix 3). For some countries, sample sizes are low (e.g., Hungary, n =

Table 1

Number of responses to all questions reported in this study (a), the response rate out of the total number of responses lodged (n = 3,738) (b), and the response rates (n and % of sample) to descriptive questions of survey respondents examined in this study (c).

(a) Number of respondents to all five questions reported in this study	(out of 3,738 participants)	1,449		
(b) Response rate for all five questions in the study	38.76 %			
(c) Description	Response	n	% of sample	
Age distribution	≤30	100	6.90	
	31–50	516	35.61	
	51–70	677	46.72	
	≥71	156	10.77	
	NA	0	0.00	
Language distribution	English	1,243	85.78	
	German	201	13.87	
	Spanish	5	0.35	
	NA	0	0.00	
Country distribution	Australia	317	21.88	
	Canada	24	1.66	
	Germany	195	13.46	
	UK	40	2.76	
	USA	846	58.39	
	Others* (16)	27	1.86	
	NA	0	0.00	
Education	Primary	2	0.14	
	Upper Secondary	80	5.52	
	Practical/Technical/Occupational	209	14.42	
	Bachelor or equiv.	496	34.23	
	Master or equiv.	435	30.02	
	Doctoral or equiv.	201	13.87	
	Other	26	1.79	
	NA	0	0.00	
	Self-identified gender distribution	Male	216	14.91
		Female	1204	83.09
Gender diverse		10	0.69	
Gardening experience in years	Prefer not to answer	19	1.31	
	Less (<10 years)	547	37.75	
Difficulties experienced	More (≥10 years)	902	62.25	
	Few (0–2)	988	68.18	
	Some (3–5)	418	28.85	
Food concerns experienced	Many (6–9)	43	2.97	
	Few (0–2)	681	47.00	
	Some (3–5)	614	42.37	
	Many (6–12)	154	10.63	
Challenges faced	Few (0–1)	839	57.90	
	Some (2–4)	560	38.65	
	Many (5–7)	50	3.45	
Gardening size**	Small	103	7.11	
	Medium	354	24.43	
	Large	809	55.83	
	Very large	183	12.63	

* Indicates countries with <10 respondents per question.

** See Appendix for description.

1; Philippines, n = 2) and present a limitation to any generalizations to a nation-level. Thus, our study does not look at regional differences and instead analyzes responses across geographic contexts to avoid making comparisons among countries with an uneven sample size. Respondents were mostly from the Global North; the results represent people within these countries.

As a preliminary analysis to understand the geospatial distribution of the respondents and their geographic context (e.g., whether in an urban area), we analyzed the landscape characteristics of respondents, specifically landscape imperviousness. Here we extracted the *Qualtrics*’ GPS coordinate (Latitude, Longitude) for the survey respondent where it was available. If the respondent completed the survey using the *Qualtrics* Offline Application on a GPS-enabled device, these data will be an accurate representation of the respondent’s location. For all other respondents, the location is determined by *Qualtrics* by comparing the participant’s IP address to a location database. With the US responses, we crosschecked the provided zip codes with the IP address, which confirmed the location. From these geographic data, we calculated the average amount of impervious land cover within a 1 km buffer from each of the respondents from the Global Urban Footprint (GUF) project, a global database of the mapping of settlements with a ~12 m spatial resolution (<https://www.dlr.de/eoc/>), which is the highest currently publicly available at global scale. GUF is derived from the TerraSAR-X and TanDEM-X image datasets through i) a first analysis of ‘speckle divergence’, i.e., the highlight of regions with high backscattering which is typical of built-up areas in radar imagery, ii) a second automated image classification procedure to separate built-up vs non-urban areas, and iii) a final postprocessing, mosaicking and validation phase (more details are in (Esch et al., 2014) and references therein). This is a globally-comparable estimate of the urban landscape composition around each respondent (0% = completely rural; 100 % = completely urban).

The final dataset is available on FigShare: 10.6084/m9.figshare.18131009.

2.2. Data analysis and synthesis

We calculated summary statistics of self-reported sociodemographic variables, including age and gender identity, gardening experience, and garden size (where relevant) to describe survey respondents. For gardening experience, we grouped responses into two groups: those with 10 years of experience or less (including first time gardeners) and those with more than 10 years of experience based on preliminary analysis of the distribution of the data to maintain some balance in sample sizes among experience levels. All statistical analyses were performed in R v.3.6.0 (R Development Core Team, 2016).

For three survey questions with multiple responses (challenges, difficulties, concerns; Appendix 1), we summarized and analyzed the data by (i) creating a response matrix of binomial (yes-no) responses, and (ii) summarizing the number of “yes” responses to count the total number of challenges, difficulties and concerns experienced by each respondent, respectively. Each of these response matrices (challenges, difficulties, concerns) collapsed into one variable, where higher values indicate more challenges, difficulties, and concerns experienced. Finally, we created three ordinal groups for each of the questions to order the respondents based on the total number of reported number of challenges, difficulties and concerns: “few”, “some”, and “many” (Table 1).

To determine what people value the most in gardening during the pandemic (Q1), we calculated the distribution of responses for the questions on the importance of gardening and changes in gardening activity due to COVID-19 using the *likert* function and package in R (Bryer and Speersneider, 2015). In addition, for the question on the importance of gardens during COVID-19 and the changes in gardening activity and interest, we performed a Spearman Rank test using the *cor* function in the Performance Analytics package in R (Peterson et al., 2020) to determine which responses were significantly associated with

one another. This allowed us to measure whether there are associations among benefits and changes in gardening activity and interests.

To test to what extent people's experience in gardening mediates their response during the COVID-19 pandemic (Q2), we analyzed whether gardening activity and interest and gardening-related challenges vary with gardening experience. We used ordinal logistic regression models fit with a probit link function that included gardening experience level ("less": ≤ 10 years; "more": > 10 years; level determined by high proportion of respondents with > 10 years' experience) as a predictor variable, and the (i) five gardening activity and interest components (three levels), and (ii) the number of challenges experienced (two levels) as the ordinal response variables. The ordinal logistic regression was followed by an analysis of deviance and a Tukey-adjusted pairwise comparisons of means test to statistically compare differences between groups using the *lsmeans* package in R (Lenth and Herve, 2016). Model assumptions were confirmed using residual-vs-covariate plots and Q-Q plots using the 'sure' package in R (Greenwell et al., 2017).

To test whether people value gardening more if they faced more personal hardships during the COVID-19 pandemic (Q3), we used ordinal logistic regression models fit with a probit link function using *clm* in ordinal (Christensen, 2019) to test for relationships between the number of COVID-related daily difficulties and number of concerns about accessing food with: (i) each of the eleven components on the importance of gardening, and (ii) each of the five components on changes in gardening activity. For this analysis, we reclassified the response variables due to skewed distribution across the dataset following others (Vierssen Trip et al., 2020). For the importance of gardening responses, we reclassified the 5-Point Likert scale responses into three ordinal responses: "not important" (1 on scale; "not at all important"), "somewhat important" (combined 2, 3 and 4 on scale; "slightly important", "moderately important" and "very important"), and "very important" (5 on scale; "extremely important"). For the changes in gardening activity responses, we also reclassified responses into three ordinal responses: "less" (combined "much less" and "less"), "same" ("same/no change"), or "more" (combined "more" and "much more"). The ordinal logistic regression was followed by an analysis of deviance and a Tukey-adjusted comparisons of means test to compare between the three groups using the *lsmeans* (Lenth and Herve, 2016). Model assumptions were confirmed using residual-vs-covariate plots and Q-Q plots.

3. Results

3.1. Description of survey respondents

Of the fully completed surveys analyzed here ($n = 1,499$ of 3,743 surveys lodged), most of the respondents live in urban areas (mean landscape imperviousness 66 ± 31 %; range 0 %–100 % urban), with nearly half of respondents located in highly urbanized landscapes ($n = 641$ (44 %) in 80–100 % impervious landscapes) (Appendix 4). Fewer respondents lived in rural landscapes (e.g., $n = 136$ (9 %) in ≤ 10 % impervious landscapes). A majority of respondents were middle age (mean 53 ± 15 years; range 20–87 years old) and women ($n = 1,204$; 83 % of total), and had over 10 years of gardening experience ($n = 902$; 62 %) (Table 1). Of those new to gardening and with less experience (< 10 years), reasons for gardening during the pandemic included uncertainty about the fragile food supply during the pandemic, more time to garden, a new space to garden, or sought a recreational outdoor activity, among other motivations (Cortez et al., 2022). A majority of the respondents were gardening in a plot that was relatively large, encompassing a back- or front-yard ($n = 809$; 56 %) or a residential lot ($n = 183$; 13 %). Of the remaining, 24 % gardened in raised beds or garden plots, and 7 % gardened in just a few pots and planter boxes (e.g., balcony gardening). Surveys analyzed here were taken mostly in English ($n = 1,243$; 86 %) followed by German ($n = 201$; 14 %) and Spanish ($n = 5$; < 1 %).

3.2. What do people value the most in gardening during a global pandemic? (Q1)

'Connecting to nature' and 'relaxation and stress release' were the most important benefits of gardening across all respondents with 89 % and 87 % reporting that these reasons were 'extremely important' or 'very important' (Fig. 1a; Appendix 5). This was followed by 'outdoor physical activity' (78 %) and 'food production and/or food quality' (53 %). 'Earning money' and 'saving money' were the least commonly reported benefits of gardening during the COVID-19 pandemic, with 90 % and 58 % of gardeners reporting that they were not at all important. In the preliminary data exploration, we found that several of the factors around the importance of having a garden were correlated, indicating that they were often reported together (Appendix 6). This included significant positive associations between: food production and knowing where food comes from (Spearman-rank Correlations; $\rho = 0.651$; $p < 0.001$); connecting to nature and outdoor physical activity ($\rho = 0.527$; $p < 0.001$); connecting to nature and relaxation and stress-relief ($\rho = 0.464$; $p < 0.001$); food production and saving money ($\rho = 0.503$, $p = 0.004$), food production and sharing plants/food ($\rho = 0.465$, $p = 0.006$); fostering culture and learning/educating ($\rho = 0.416$; $p = 0.005$); and saving money and sharing plants/food ($\rho = 0.415$; $p = 0.006$).

Across all respondents, people reported that they spent more time gardening (65 % reporting 'more' or 'much more') during the pandemic compared to previous years (Fig. 1b; Table 2). In addition, a majority of people reported that they planted or planned to plant more (58 %) and hoped to produce more (54 %). None of these responses were related to one another (Appendix 7).

3.3. To what extent does people's previous gardening experience influence their responses to gardening-related challenges during the COVID-19 pandemic? (Q2)

Gardening experience did not predict differences in the self-reported number of challenges to gardening during the COVID-19 pandemic ($X^2 = 1.28$, $P = 0.26$) (Fig. 2; Appendix 8). However, newer gardeners (≤ 10 years of experience) reported that they spent significantly more time gardening ($X^2 = 28.01$, $P < 0.001$), are planting more ($X^2 = 43.71$, $P < 0.001$), and expected to produce more ($X^2 = 36.08$, $P < 0.001$) during the pandemic than seasoned gardeners with more than 10 years of experience (Fig. 2). Furthermore, newer gardeners reported that they connected with others more through gardening ($X^2 = 16.21$, $P < 0.001$), and sought more gardening information ($X^2 = 49.64$, $P < 0.001$) (Appendix 9).

3.4. Do people value gardening more if they faced more personal hardships during the COVID-19 pandemic? (Q3)

People reported challenges, difficulties and concerns related to the COVID-19 pandemic during the time of the survey. Half of all respondents felt isolated, anxious, and/or depressed (Appendix 9). Moreover, 81 % of respondents had concern about food access, with high concerns about exposure to the virus while obtaining food ($n = 853$; 59 %), and about the limited selection and/or quantities of food at the store ($n = 811$; 56 %). One in two respondents were concerned about empty shelves at the grocery store ($n = 702$; 48 %) and one in four about food shortages ($n = 307$; 21 %). In relation to their gardening, a majority of respondents experienced some sort of challenge to gardening due to the COVID-19 pandemic (72 %). The most commonly selected challenges included getting materials in plant nurseries and stores ($n = 804$; 55 %) and too little interaction with other gardeners ($n = 370$; 26 %).

The number of reported COVID-19-related difficulties was significantly related to the importance of gardening for food provision and knowing where food comes from, connecting to nature, cultural identity, and economic benefits (both saving and earning money) (Appendix 8; Fig. 3). However, the number of respondents facing many challenges

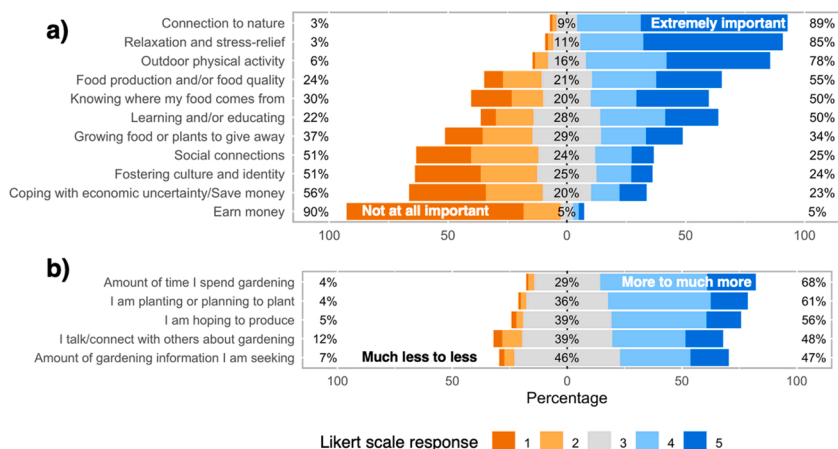


Fig. 1. (a) Distribution of responses (n = 1,499) to the question “During COVID-19, how important are the following reasons for having a garden? Please rate them on a scale of 1 to 5,” where more importance is indicated in blue on the right side of the panel and less importance in orange on the left side. (b) Distribution of responses (n = 1,499) to the question “Has the COVID-19 pandemic changed the way you garden compared to previous years? Please indicate if you are doing something more, less, or if there has been no change”; ‘much more’ is indicated in dark blue and ‘more’ in light blue on the right side of the panel; ‘much less’ is indicated in dark orange and ‘less’ in light orange on the left side of the panel; gray represents ‘same/no change’. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

Table 2

Summary of responses (sample size (n) and percent of total (%)) to the five-component question “Has the COVID-19 pandemic changed the way you garden compared to previous years? Please indicate if you are doing something more, less, or if there has been no change”.

	The amount of time I spend gardening		I am planting or planning to plant		I am hoping to produce		I talk/connect with others about gardening		Amount of gardening information I am seeking	
	n	%	n	%	n	%	n	%	n	%
Much less	13	0.90 %	13	0.90 %	13	0.90 %	13	0.90 %	13	0.90 %
Less	38	2.62 %	38	2.62 %	38	2.62 %	38	2.62 %	38	2.62 %
Same/No change	416	28.71 %	416	28.71 %	416	28.71 %	416	28.71 %	416	28.71 %
More	675	46.58 %	675	46.58 %	675	46.58 %	675	46.58 %	675	46.58 %
Much more	307	21.19 %	307	21.19 %	307	21.19 %	307	21.19 %	307	21.19 %
Grand Total	1449	100.00%	1449	100.00%	1449	100.00%	1449	100.00%	1449	100.00%

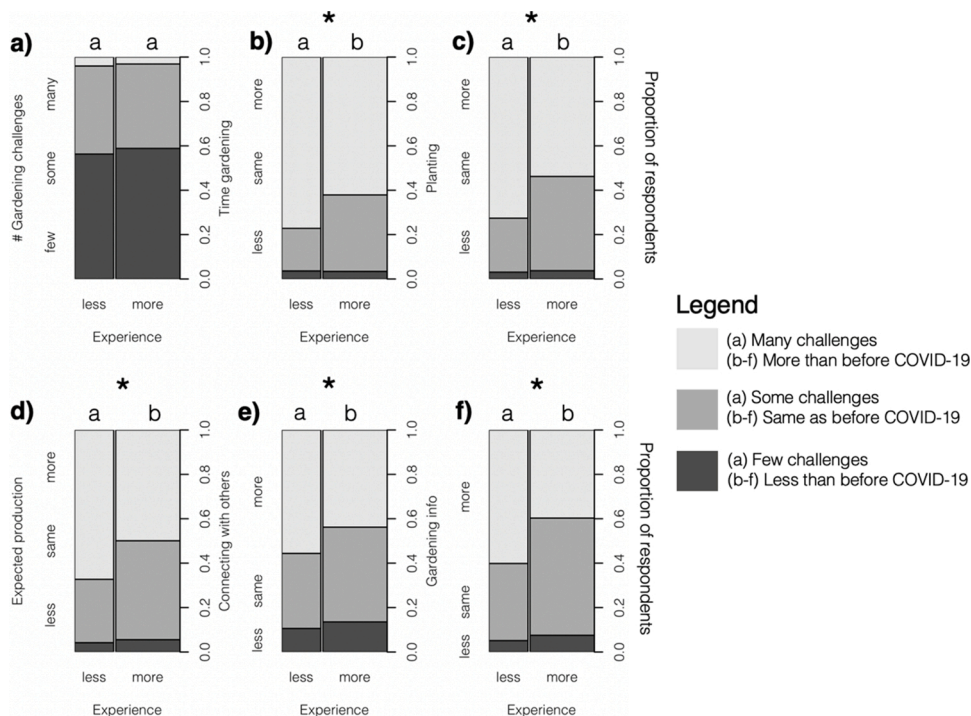


Fig. 2. Relationships between gardening experience of respondents (x-axis, categorical: less = <10 years; more = ≥10 years) and the number of challenges to garden due to COVID-19 (y-axis, categorical; few, some, many challenges) (a), and the changes in gardening activity (y-axis, categorical: less, same/no change, more) due to COVID-19 (b-f). Y-Axis is the proportion of respondents within a respective response category. Asterisk(s) represent significant p-values in analysis of deviance tests. The plots represent distribution of data, where the relative proportion of responses within a category (few, some, many (a); less, same/no change, more (b-f)) is represented by the size of the box. Letters indicate significant differences between the experience groups.

was low (n = 43; 3% reported many challenges, i.e., more than six of nine possible challenges). Furthermore, COVID-19-related difficulties significantly predicted changes in gardening activity during the pandemic. Here, people facing more difficulties associated with the COVID-19 pandemic were more likely to report spending more time

gardening, planting or planning to plant more, expecting to produce more, connecting with others more, and seeking more information about gardening than in previous years.

Food related challenges significantly predicted the importance of gardening for: food production and knowing where produce comes

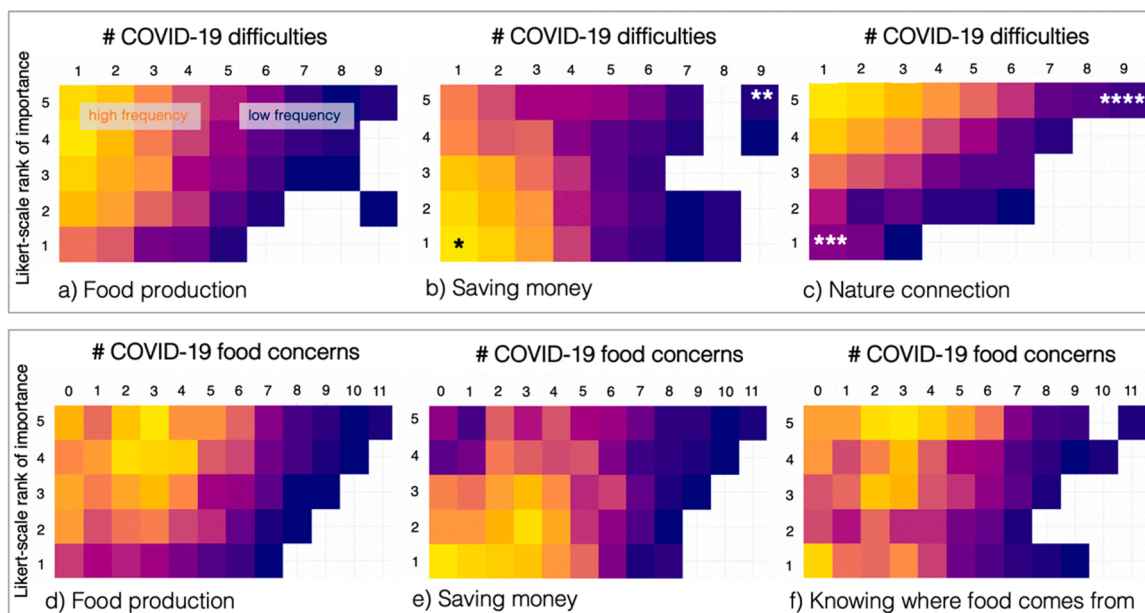


Fig. 3. Relationships hypothesized to be important – here represented as frequency heat maps – between the number of reported difficulties that respondents faced during the COVID-19 pandemic and the importance of gardening for food production (a), saving money (b), and nature connection (c) during the pandemic (Likert scale 1-5 of increasing importance). Relationships between the reported number of food concerns during the COVID-19 pandemic and the importance of gardening for food production (d), saving money (e), and knowing where food comes from (f) during the pandemic (Likert scale 1-5 of increasing importance). Dark purple blocks indicate lower frequency (or density) of respondents with the response, whereas yellow and orange blocks indicate higher frequency (or density) of respondents. For example, in b, many respondents with few COVID-19 difficulties reported that saving money through gardening was not at all important (*), while for the few respondents with many food concerns, saving money was very important (**). On the other hand, in c, very few respondents reported that nature connection was not important, regardless of how many difficulties they reported to experience (***) , instead ranking high importance of nature connection across difficulties reported (****). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

from; education and sharing food and plants; cultural identity; and economic benefits (both saving and earning money) (Appendix 8; Fig. 3). Although the number of food related challenges across respondents was low (e.g., $n = 22$ (0.75 %) with more than eight of eleven possible food related challenges), those reporting more food concerns in our sample were more likely to report greater importance of food production in gardens, of the cost savings of gardens, and to knowing where food comes from. In addition, those with some to many food concerns generally spent more time gardening, were planting or planning to plant more, expecting to produce more, connecting with others more through gardening, and seeking more information about gardening than prior to the pandemic.

4. Discussion

Gardening during the early stages of the COVID-19 pandemic was important to many people for nature connection, individual stress release, outdoor physical activity and food provision. In addition to biophilic (nature connection) and outdoor benefits, the importance of food provision and subsequent economic security were important for those facing greater hardships from the pandemic. The literature on gardening has long demonstrated the multiple benefits of gardening (Soga et al., 2017; Thompson, 2018). Our results show that these benefits have persisted during COVID-19 and were amplified among people most stressed by the pandemic, as captured in our sample.

4.1. The value of gardening during the COVID-19 pandemic

We hypothesized that gardening would be highly valued for food provisioning and food access, therapeutic (stress release) and economic benefits during the pandemic (H1). In support of our predictions, gardening was highly valued across respondents as important for connecting to nature, relaxation and stress release, and as an outdoor

physical activity (Fig. 1). This is in line with clinical research demonstrating the importance of gardening for reducing acute stress (Chalmin-Pui et al., 2021; van den Berg and Custers, 2011). Furthermore, it is in line with work in community gardens on how gardeners value their gardens for perceived wellbeing benefits including food provisioning, mental health and connection to nature (Egerer et al., 2018; Marsh et al., 2018).

Compared to previous years, most respondents spent more time gardening, planted more plants, and hoped to produce more fresh food. This is in line with findings that the interest in gardening peaked during the early waves of the COVID-19 pandemic as lockdowns in different countries confined people at home (Lin et al., 2021). This further resonates with evidence suggesting that, at the local level, gardening membership at some community gardens spiked during summer 2020 in the Northern hemisphere (Mejia et al., 2020) and home gardening increased in popularity (Corley et al., 2021). Furthermore, it corroborates case studies showing how an urban green landscape, including a city park and domestic gardens, have provided an oasis for mental restoration, physical exercise, and food provision during the COVID-19 pandemic (Home and Vieli, 2020; Ugolini et al., 2020).

The surge in gardening interest, activity and value shown in the popular media (Atkinson, 2020; Evans and Davies, 2020), other studies (Corley et al., 2021; Lin et al., 2021; Marsh et al., 2021; Schoen et al., 2021) and highlighted here in our results emphasizes the heightened importance of gardening during time of crisis, from natural disasters to economic crashes and political unrest. Specifically, literature shows that gardening is a practice for resilience and hope during social upheaval and crises (McClintock, 2010). Gardening is not only an immediate coping mechanism to disruptions, but also can engender community resilience to sudden change in the future (Barthel and Isendahl, 2013). For example, during economic recession, neighborhood grassroots gardening initiatives may recultivate vacant lots to create community and sense of purpose evident in the New York City recession (Staehele,

2008; Staeheli et al., 2002). During wartime, coordinated government gardening initiatives may support food security, economic savings, and citizen activism; noteworthy examples include ‘Victory Gardens’ in the Second World War in the UK (Ginn, 2012) and the USA (Lawson, 2005). After earthquakes, community gardens can support post-quake recovery through heightened social interactions that foster community support and by providing a space to de-stress (Shimpo et al., 2019). After hurricanes, gardens may ensure food security (Sims-Muhammad, 2012) while empowering people to participate in disaster recovery activity (Kato et al., 2014). Thus, gardening during the pandemic may represent a contemporary example of how this practice can be a response for people facing crises and disasters (Schoen et al., 2021).

The importance of gardening for connecting to nature and for outdoor physical activity were highly important, and also synergistic (correlated) with one another in our sample. Gardeners seem to be coping with crisis during this time by interacting with their plants (Pérez-Urrestarazu et al., 2021; Theodorou et al., 2021). In the pandemic context, this supports evidence that many people sought access to greenspaces during the respective first lockdowns in each country to build their resilience to the acute social disruption (Samuelsson et al., 2020; Soga et al., 2021). But it is also in line with the wider body of literature on how biophilic interactions through gardening can facilitate stress release and improve human health (Lin et al., 2018; Russell et al., 2013; Soga et al., 2017; Thompson, 2018; Ulrich, 2002). Much evidence shows that knowing and experiencing nature makes us generally mentally and physically healthier and happier people (Russell et al., 2013). Through gardening activity, people are exposed to natural elements and biodiversity in their surroundings (Lin et al., 2018) – in our study, often in their own backyards, as a majority of our respondents reported that is where they are gardening.

The reported stress relief by these respondents through gardening suggests that gardening is an accessible and affordable activity that can maintain and improve human mental and physical health (Soga et al., 2017) and could be incorporated into mainstream health care systems and subsidized by public health institutions (Thompson, 2018). Gardening can reduce acute stress endocrine biomarkers (e.g., cortisol) and promote positive mood (van den Berg and Custers, 2011). This is often increased thanks to plant-animal-human interactions and access to fresh air (Thompson, 2018). These biological mechanisms are part of a wide range of psychological, social and ecological factors that individually or collectively contribute to gardens and greenspaces function as therapeutic landscapes (Marsh, 2020). Furthermore, the enhanced connection to nature during time of hardship can provide an opportunity for strengthening tie to biodiversity, which in turn can further elevate positive public health outcomes (Flies et al., 2017).

4.2. Experience influences responses to gardening

We hypothesized that gardeners with longer experience gardening would report fewer gardening-related challenges and less changes to their ongoing gardening activity and interest (H2). We found partial support for this hypothesis. Newer gardeners in our sample – defined here as those with less than ten years of experience – spent more time gardening during the pandemic than their more experienced counterparts with over ten years of gardening history. This trend is likely a function of age and employment, with those people who have gardened longer than ten years more likely to be older and retired with more time to garden. Thus, older gardeners may be less impacted than younger gardeners by changes in daily schedules disrupted by the pandemic (e.g., working from home; more flexible working hours; kids homeschooling). In addition, and perhaps not that surprising, newer gardeners might be seeking more information during COVID-19 (Lin et al., 2021) and connecting to others more through their gardening activity and interest. Gardening takes some baseline knowledge, and we may expect that those who are newer to gardening might be seeking more information on germinating seeds, making compost, managing pests or establishing an

irrigation system. Gardening can be a point of social connection – the development of social bonds and networks – with neighbors over a fence, dogwalkers passing by, and with other community gardeners (Alaimo et al., 2010). For example, residents in Brisbane, Australia, have cultivated their roadside verges with vegetables and flowers and have consequently developed strong bonds with their neighbors (Dillon, 2020). In community gardens, social connection benefits include increased social cohesion through sharing and social support by having people to turn to in times of crisis (Kingsley et al., 2020).

Surprisingly, both new and seasoned gardeners faced on average a similar number of challenges – mostly around accessing materials to garden (e.g., 55 % reported difficulty accessing seeds). Previous work shows that less experienced gardeners perceive more challenges in crop production (e.g., pest control) (Liere et al., 2020), and that there are differences in how novice versus experienced gardeners adapt to specific horticultural challenges (e.g., drought) (Egerer et al., 2020). Here, however, the similar number of challenges faced by all gardeners in our sample may be because the most common challenges during the pandemic are not those related to garden management or production, which might be more easily solved by additional horticultural knowledge and experience. Rather, the widespread shortages of seeds and seedlings for planting in stores, for example, impacted people regardless of their years gardening. While gardeners with more experience might be slightly better positioned to grow their own seedlings or to save seeds from previous crops, it is hard to deploy those skills *after* a shortage materializes.

4.3. Personal hardships during the COVID-19 pandemic can influence the value of gardening

We hypothesized that increased self-reported COVID-19-related daily difficulties would increase the perceived importance of gardens and time spent gardening than those with fewer difficulties, especially around self-provisioning benefits and economic relief benefits of gardening (H3). Across all respondents, a large majority (81 %) reported having concerns about accessing food during the COVID-19 pandemic, and most (>50 %) respondents were concerned about going to the grocery store or about their ability to access fresh food (Appendix 5). In support of our hypothesis, those with more food concerns placed more importance on food provisioning and economic benefits arising from gardening, in addition to nature connection benefits described above. Important to note is that our sample is biased towards educated people, those with internet access, and who may already have a space to garden at home, meaning that we are likely limited to capture those both food- and economically-insecure. Nevertheless, gardening was not only important for connecting to nature, stress reduction, and outdoor activity, but seems to have provisioned fresh and affordable fruits and vegetables for gardeners who were experiencing more economic hardship during the pandemic (e.g., job loss). Gardening can increase food security and access for vulnerable food-insecure population, particularly when needed the most (Alaimo et al., 2008; White, 2011). Although the gardeners experiencing extreme food insecurity with multiple food-related concerns in our respondent pool were few, self-provision remains a key motivation of home gardeners, community gardeners and small-scale food producers worldwide (Altieri et al., 1999; Čepić and Tomičević-Dubljević, 2017; Egerer et al., 2019; Pourias et al., 2016; Taylor et al., 2016).

Recent public health surveys indicate that families spent less on groceries and found it difficult to afford food during the pandemic. For example, in Los Angeles County (USA), 40 % of low-income households experienced food insecurity during the first lockdown period (de la Haye et al., 2020). In the entire US, a report showed sharp increases in food insecurity in April 2020 during the lockdown, with food insecurity estimates doubling and tripling for households with children (Schanzenbach and Pitts, 2020). Media chronicles further highlight how community gardening has aimed to address and mitigate COVID-19

related food insecurity for vulnerable populations (e.g., in Launceston, Tasmania, where many experienced significant food insecurity (Champ, 2020)). Thus, ensuring food security through agricultural diversification and landscape multifunctionality is critical to mitigate shocks on food distribution networks (Aday and Aday, 2020; Lal, 2020; Steenkamp et al., 2021). Yet, while the land for urban agricultural production is often present in many cities (Edmondson et al., 2020), equitable access to gardens is needed to guarantee multiple gardening benefits for all sectors of the population, especially those most vulnerable.

4.4. Limitations and recommendations for future research

What we will learn from this moment in history and how it will inform post-pandemic policy, landscape planning and design are open questions. This is important particularly for areas where populations who experience the greatest health vulnerabilities live. Here we provide evidence for the importance of gardening and changes in gardening activity during the COVID-19 pandemic among a sampled population. Yet, it remains to be seen whether gardening will maintain its importance for mental and physical health post-pandemic as people return to work and social activities, which may mean less time at home and in nearby nature, access to other forms of stress release, and more income for food. Will people go back to a life characterized by store-bought groceries and savings towards international vacations rather than for new gardening boxes, seeds and plants? Will we stop sharing garden produce with our neighbors over the fence? Will we dismiss the benefits that gardening and fresh air provides for stress release and mental health?

We recommend further research to answer such questions, considering the limitations of our study. First, we need to track longitudinal opinions on gardening and changes in gardening access and activity with a larger sample of people with varied gardening history and activities across a wider range of demographics – especially vulnerable populations. In our research, we show a common trend of experienced, female, older participants that are gardening at home. While the age and gender distributions are typical of similar survey responses on gardening (Gillis and Swim, 2020), these respondents may not be experiencing more critical issues with land access or food insecurity, and we acknowledge that few of our respondents are experiencing extreme food insecurity (Appendix 4). Thus, the presented work is limited in its ability to answer nuanced questions around food security and economic challenges in relation to gardening, but the survey tool we employed could be adapted to other regions to draw comparisons. Future studies should target communities from the Global South to answer such questions around food security that may have occurred later in the pandemic's trajectory, as our findings are largely limited to the Global North during the pandemic's first wave. As COVID-19 first hit many industrialized and western countries in the Global North in early 2020 (Lin et al., 2021), our analysis consequently missed e.g., developing nations that were affected by COVID-19 after our survey was released. Work in the Global South shows the importance of urban agriculture for food security, including both access and stability to food during shocks (Mougeot, 2000; Steenkamp et al., 2021). Furthermore, inequalities in private land ownership in urban areas exacerbate the already disparate impact of the COVID-19 pandemic across populations by limiting access to land and resources for gardening (Ossola et al., 2018b). More research is needed to capture variations in public sentiment and practice – particularly including those who do a little gardening, have less access to land, and reside in low-income communities.

Second, due to the nature of agricultural production, our survey timeframe may not have captured the peak harvest of gardening activity across all respondents in different countries, which could influence the perceived value of food production-related benefits. While our survey synchronized with the main harvest in the southern hemisphere (e.g., Australia), we may have missed a portion of high production in the later season for the northern hemisphere in September to October 2020.

Future research should investigate whether food benefits from gardening can improve food security throughout the “waves” of the pandemic worldwide, especially in the Global South. Third, previous work shows that gardeners with decades of gardening experience tend to utilize knowledge intensive practices, while those more recent to gardening readily adopt technological practices (Egerer et al., 2020). It may be interesting to follow how experience within the pandemic context shapes changes in specific management practices, and how this may impact ecological characteristics and functions of gardens.

Third, our results raise questions about the access to and availability of gardens. A large proportion of respondents were urban gardeners, with nearly half being in very impervious surroundings (>80 % imperviousness), and over half with yard-size gardens. For our analysis, we focused on those that were active in gardening already, to directly ask questions about realized benefits and experiences of active gardeners. What we could not capture, and what remains to be investigated, is whether some social groups were excluded from these gardening benefits during the pandemic due to lack of private land access (reflecting those less likely to respond to our survey), and the landscape characteristics in which they live. What our results show, is that pandemic gardening is positively valued in our sample (of those educated, with garden access and internet access) but likely beneficial for all who suffer challenges and health inequalities during crises.

Finally, we could not predict the speed, impact or severity of the pandemic, and how it would affect various people of different backgrounds. In our interdisciplinary team, we swiftly developed and tested a survey instrument within a short time frame to distribute around the world. However, our questions on difficulties, challenges, and concerns experienced may not have fully captured all of the disparate life experiences of gardeners, simply because they were difficult, if not impossible, to predict *a priori*. Furthermore, we could not perform a before-and-after assessment to determine the acceleration of interest in gardening or amplification of benefits, leaving room for future research to perform before-after assessments that also utilizes qualitative responses of people's experiences to inform whether and how the interest in and benefits of gardening changed over time.

5. Conclusion

As we write this, the state of the world is still bleak, and the future is unclear. Yet, in gardens and gardening people may still find a sense of hope (Marsh et al., 2021). Gardening is a powerful strategy to cope with stress through outdoor activity, and for provision of food security during periods of uncertainty. Planning and public health measures must continuously foster the multiple benefits of gardening especially for nature connection and stress release, not just in crises. As landscape multifunctionality is increasingly seen as the beacon for landscape design, planning and policy especially in cities (Andersson et al., 2019; Lovell and Taylor, 2013; Meerow and Newell, 2017), the challenges posed by the COVID-19 pandemic can provide important and novel insights into the multiple needs of populations, where needs vary depending on garden access and distribution in human landscapes (Steenkamp et al., 2021). To extrapolate from the findings of this work around the importance of gardening during the pandemic, we support some key interventions particularly for urban areas for moving forward with this agenda:

- *Formalize gardening as a legitimate outdoor public health initiative, as it can help people to cope during a pandemic and other disruptions;*
- *Create opportunities for engaging new gardeners, while identifying and removing barriers to entry for new gardeners;*
- *Utilize this unique opportunity to rethink landscape planning, design and policy to increase gardening and urban agriculture in public spaces, as well as redress unequal distribution of productive landscapes in cities to ensure that, if other pandemics occur, all populations are well equipped to cope through gardening.*

Our work shows the value of gardening, and some changes in gardening interest and activity for some people during the early stages of the COVID-19 pandemic across several developed countries. Gardening can offer an array of positive biophilic interactions to treat acute stress, while also being an important food system resilience strategy by incorporating agricultural spaces to diversify production sources. In conclusion, gardening should be readily accessible and available to all people for current and future societal health.

Author statement

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Data availability

Data is available on the FigShare website: 10.6084/m9.figshare.18131009.

Declaration of Competing Interest

The authors have no relevant financial or non-financial interests to disclose. The authors have no conflicts of interest or competing interest to declare. The research was carried out with approval by the appropriate ethics committee for research.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.ufug.2022.127483>.

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