Lenda, M. L., P. Skórka, M. Jaźwa, H.-Y. Lin, E. Nęcka, P. Tryjanowski, D. Moroń, J. M. H. Knops, and H. P. Possingham. 2023. Recognizing the importance of near-home contact with nature for mental well-being based on the COVID-19 lockdown experience. Ecology and Society 28(3):13. https://doi.org/10.5751/ES-14374-280313

Research

Recognizing the importance of near-home contact with nature for mental well-being based on the COVID-19 lockdown experience

Magdalena L. Lenda[1,2], Piotr Skórka[1], Małgorzata Jaźwa[3], Hsien-Yung Lin[4,5], Edward Nęcka[6], Piotr Tryjanowski[7], Dawid Moroń[8], Johannes M. H. Knops[2] and Hugh P. Possingham[9]

ABSTRACT. Several urban landscape planning solutions have been introduced around the world to find a balance between developing urban spaces, maintaining and restoring biodiversity, and enhancing quality of human life. Our global mini-review, combined with analysis of big data collected from Google Trends at global scale, reveals the importance of enjoying day-to-day contact with nature and engaging in such activities as nature observation and identification and gardening for the mental well-being of humans during the COVID-19 pandemic. Home-based activities, such as watching birds from one's window, identifying species of plants and animals, backyard gardening, and collecting information about nature for citizen science projects, were popular during the first lockdown in spring 2020, when people could not easily venture out of their homes. In our mini-review, we found 37 articles from 28 countries with a total sample of 114,466 people. These papers suggest that home-based engagement with nature was an entertaining and pleasant distraction that helped preserve mental well-being during a challenging time. According to Google Trends, interest in such activities increased during lockdown compared to the previous five years. Millions of people worldwide are chronically or temporarily confined to their homes and neighborhoods because of illness, childcare chores, or elderly care responsibility, which makes it difficult for them to travel far to visit such places as national parks, created through land sparing, where people go to enjoy nature and relieve stress. This article posits that for such people, living in an urban landscape designed to facilitate effortless contact with small natural areas is a more effective way to receive the mental health benefits of contact with nature than visiting a sprawling nature park on rare occasions.

Key Words: *birdwatching, citizen science, COVID-19, eBird, gardening, iNaturalist, lockdown, mental health, mental well-being, nature observation, plant identification, small local areas, stress*

INTRODUCTION

The COVID-19 pandemic and its consequences have dramatically changed human life. Following the World Health Organization's call to slow down the transmission of SARS-CoV-2 virus (World Health Organization 2020), many countries implemented strict social distancing policies. Such restriction of movement and related uncertainties gave rise to negative emotions, affecting people's mental well-being (Cullen et al. 2020, Marroquín et al. 2020, Pfefferbaum and North 2020) and reducing life satisfaction (Zacher and Rudolph 2021). Stress, fear, and sadness are negative emotions that can be reduced by social activities, such as time spent with family (Evans et al. 2020) or friends (Lippke et al. 2021), online meetings (Issa et al. 2021, Brouzos et al. 2023), and physical activities (Lippke et al. 2021). Apart from these activities, contact with nature has been found to be beneficial for mental well-being both before (Bratman et al. 2019) and during the pandemic (Oh et al. 2021a, 2021b). Psychological studies have shown that at least 120 min of contact with nature per week, increasing up to 200–300 min per week, improves people's mental well-being (White et al. 2019). Such health benefits provided by nature to humans can be considered as ecosystem services (Bratman et al. 2019). Ecosystem services are defined as nature's contributions to human quality of life or economy (Millennium Ecosystem Assessment 2005). Contact with nature through walks; gardening; observation of wild plants, fungi, animals, and their identification as entertainment; or simply tree gazing from one's window may bestow substantial mental health benefits (Bartlomiejski and Kowalewski 2019, Oh et al. 2021a, 2021b). Such activities can be performed not only in nature-rich areas but also in urbanized landscapes, such as cities, towns, and villages. Recently, landscape planning concepts such as land-sharing and land-sparing have been incorporated into urban ecology to link green nature areas with the economy in urban environments (Green et al. 2005, Soga et al. 2014). Land sharing suggests that land should be developed at a low intensity, accommodating at least some green areas with vegetation, such as trees, grass, or even mini-parks, placed between buildings. In contrast, land sparing calls for a sharp division between urban and green spaces: that is, maximizing building density and minimizing green space in human settlements, while allocating dedicated large areas for green spaces, such as urban parks, city forests, meadows, lakes, and so on (Soga et al. 2014). These concepts give serious consideration to the creation of green areas and their optimal spatial location among highly transformed areas dominated by concrete structures, such as buildings, markets, streets, and pavements. Nevertheless, the planning of human settlements rarely takes into account the importance of contact with nature for the mental well-being of inhabitants, despite the fact that the mental health of citizens has direct implications for the society in terms of public health needs, law and order, and economic productivity.

[1]Institute of Nature Conservation, Polish Academy of Sciences, Kraków, Poland, [2]Department of Health and Environmental Sciences at Xi'an Jiaotong-Liverpool University, Suzhou, Jiangsu, China, [3]Institute of Biology, University of Opole, Opole, Poland, [4]Institute of Environmental and Interdisciplinary Science and Department of Biology, Carleton University, Ottawa, Ontario, Canada, [5]Canadian Wildlife Service, Environment and Climate Change Canada, Gatineau, Quebec, Canada, [6]SWPS University, Krakow, Poland, [7]Department of Zoology, Poznań University of Life Sciences, Poznan, Poland, [8]Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Kraków, Poland, [9]School of The Environment, University of Queensland

Several studies have examined the mental health effects of nature activities, such as walks (Bratman et al. 2019) and animal-watching (Oh et al. 2021a) in urban forests, parks, or meadows. People usually seek to engage in these activities in places relatively little impacted by urbanization (Soga et al. 2014). Walks in green areas (Oh et al. 2021a, 2021b) and bird-watching have a positive effect on mental well-being (Cox and Gaston 2016, Murawiec et al. 2021). However, studies usually examined the effects of these activities in large spaces, such as national parks and city forests. Visiting these larger nature destinations usually requires traveling from home and involves long-distance walking, running, biking, public transportation, or car driving. During the COVID-19 pandemic, especially during the first lockdown in the spring of 2020, both traveling and visiting green areas were strictly forbidden or restricted in many countries, with financial penalties, making it difficult to be close to nature (Douglas et al. 2020). In addition, in normal daily life, many factors other than a pandemic can restrict or prevent humans from traveling to urban nature areas, especially in the case of people who are limited in their mobility, such as the elderly, disabled, or sick (examples in Table A1.1). Studies have highlighted the importance of local, home, and backyard bird feeders and the presence of birds in the immediate environment for mental well-being (Brock et al. 2017, Cox et al. 2017). A classic study by Ulrich (1984) showed that being able to view trees from the window can accelerate healing after surgery. People living near green areas in cities are happier, have less mental health problems (White et al. 2013, Oh et al. 2021a), and commit fewer crimes and acts of domestic violence (Iannone 2018) than those living away from green spaces.

These studies show that although maintaining large but distant green spaces and intensively developing human settlements might work well for nature conservation (Sushinsky et al. 2017, Ibáñez-Álamo et al. 2020), it is not an optimal conservation strategy for urbanized areas if the mental well-being of humans is taken into account (Bertram et al. 2017). Alternative concepts of urban planning, such as land-sharing, offer nature contact on a very local scale, enabling observation of nature from a window or balcony, gardening in the backyard, or simply visiting small green spaces close to buildings (Soga et al. 2014, Sushinsky et al. 2017, Semeraro et al. 2021). These nature-oriented activities on a local scale do not require traveling, making small green spaces important for many who are temporarily or permanently disabled or very busy. Such spaces were the only available option during pandemic-related lockdowns (Ugolini et al. 2021). Nevertheless, it remains to be confirmed whether this kind of local nature contact is popular, whether it is helpful for mental health problems, and whether it increases when people are forced to stay at home for longer periods. Therefore, in this study, we chose the first lockdown of the COVID-19 pandemic ("first lockdown") in the first half of 2020, as a suitable period with strict rules to study this phenomenon on a global scale.

In this study, we seek answers to four questions:

1. Were people interested in observation of nature, identification of species, or gardening as recreation during the first lockdown?
2. Were these activities helpful for mental health problems?
3. Did these interests intensify during the first lockdown?
4. What are advantages and disadvantages of these activities in relation to proximity and size of natural areas in urban environments?

We conducted a mini-review of studies examining the mental health effects of local-scale engagement with nature (e.g., watching plants and birds from a window/balcony, backyard gardening or nature observation, species identification, or visiting green spaces near one's home). This study is the first review that combines articles about nature observation, species identification, gardening, and mental health during COVID-19. We also studied trends in interests in these activities from Google Trends big data, which have not been studied so far. We conducted this study with the belief that its findings pertaining to nature contact and mental health during the lockdown should be generalized to people who, regardless of the pandemic, spend most of their time at home and cannot easily go out because of disabilities or family responsibilities. Thus, although we focus on the lockdown period, the scope of the findings and recommendations extends to normal life outside of lockdowns.

Based on our review and original data, we recommend that modern urban planning must take into consideration the mental health effects of contact with nature on inhabitants. In this study, we use modern, novel techniques rooted in iEcology, culturomics, psychology, and economics to collect global data, such as those from Google Trends.

METHODS

Study design

In order to answer the four research questions mentioned above, we took the following steps:

1. We reviewed global scientific and non-scientific press articles published in English to determine if people were interested in nature observation, gardening, and identifying different taxa in their backyards during the first lockdown.
2. We reviewed scientific and non-scientific press articles to analyze whether observing nature, gardening, or identifying different taxa in the backyard during the first lockdown were practiced as a recreational activity and whether it affected mental well-being.
3. Using big data from Google Trends, we examined whether global trends in interest in observation of nature or gardening in backyard that we found in scientific articles and non-scientific press increased during the first lockdown as compared to the five years before the pandemic.
4. Using big data from Google Trends, we examined and compared changes in global trends with regard to interest in nature-based activities that are usually performed in distant places (e.g., safari) with changes in interest in local-scale nature activities (e.g., gardening) during the first lockdown, while also comparing the trends observed to the five years before the pandemic.
5. We identified, using expert knowledge, nature contact possibilities that existed during the lockdown in small local green areas located between buildings and blocks of flats, and large but distant natural areas located in urbanized environments.

We chose the first lockdown (in 2020) because it occurred at almost the same time in most countries. Moreover, movement restrictions during that lockdown were fairly strict (with certain differences among countries) and people complied with the social distancing and isolation rules. Thus, global data pertaining to the first lockdown are more coherent and comparable.

Data collection via methods from culturomics and iEcology
The Anthropocene epoch is the era of technology and information in which global big data are generated and made available on the internet from any place in the world. Recently, scientists in many disciplines (including social, conservation, and environmental sciences) developed an interdisciplinary approach of data collection called culturomics. Culturomics is a form of computational lexicology that studies human behavior and cultural trends through the quantitative analysis of digitized texts (Jarić et al. 2020, Correia et al. 2021). Typically, culturomics involves mining digital resources to investigate cultural phenomena reflected in language and word usage. Similarly, the iEcology approach uses internet technology for collecting data on ecological topics. Collecting digital data allows for designing and performing global studies in a cost-efficient manner and decreases the carbon footprint of traditional research (Jarić et al. 2020, Lenda et al. 2020, Correia et al. 2021).

We accessed published articles using internet scientific browsers, read press articles published online, and retrieved global big data on interest in specific topics from Google Trends. Google Trends was introduced in 2006 as a web-based tool provided by Google that allows users to analyze the interest in specific search terms or topics over a given period (Jun et al. 2018). We used Google Trends to measure whether interest in activities such as nature observation, gardening, and species identification increased during the first lockdown. Google Trends measures how often a particular search item was entered into the Google Search browser relative to the total search volume. The value of Google Trends index varies on a scale from 0 to 100, with 100 indicating the peak interest for a given time and location. Time series obtained from this tool are informative for determining the dynamics of society's interest and demand for information about a species or specific topic (Vlastakis and Markellos 2012, Nghiem et al. 2016, Lenda et al. 2020), but see also limitations and strengths outlined in the study limitations section.

The categorical cluster method
This method is well established in psychology (Stone and Blumberg 2020) and economics (Rezankova 2014). The objective is to divide a set of objects into groups, called clusters. Clustering involves grouping cases or variables according to their similarity in one or more dimensions and focusing on interdependence among variables. Clustering creates groups that maximize within-group similarity and minimize between-group similarity; it also provides rich information about the individual case, which is usually the category (Dymnicki and Henry 2011).

Identifying the most common types of activities related to nature observation, gardening, and taxa identification during the first lockdown based on scientific articles and non-scientific press
For scientific articles, in March 2023 we searched Scopus and Google Scholar, because of their broad scope, with Google Scholar covering most if not all articles available in more specialized scientific browsers, such as PsycInfo, PubMed, and Medline. Under the main topics of this study, the keywords we used (Table 1) revealed redundancy between Google Scholar and Scopus, PsycInfo, PubMed, and Medline. Google Scholar covered 100% of the records found in the compared browsers and gave many more results, because it also searches whole texts, apparently using synonyms. It also finds more types of published texts, such as letters, biographies, and comments. Therefore, in order to make this study more replicable for other scientists, we decided to rely on results from Google Scholar, which is an open-source browser. For countries where Google is restricted, such as China, similar results will be available from other scientific browsers, with the highest number of results from our database (Appendix 1) being available from Scopus. We used the Google Search browser to search for globally published non-scientific press articles.

Some selection criteria were applied during article review. Specifically, we excluded articles that were not about the first lockdown; did not study activities at a local scale (from balcony, window, backyard) but rather in areas far away from home (e.g., visiting forests); studied the mental health effect of observing indoor potted plants and pet animals; or transiently mentioned the topic or keyword without going into any scientific detail.

We included all papers that met our criteria, that is, studies that analyzed our chosen topic with experiments or planned observations. We included all research papers, but not letters that made claims without any data. Google Scholar automatically screened the title, abstract, keywords, and the whole text of each article for the keywords we entered. All articles that met our criteria were read and double-checked for keywords and content related to the keywords (e.g., synonyms or if they presented content about the relevant topic without using the specific keywords). See Appendix 1 for all press and scientific articles that met our criteria and their classification.

We identified, from both types of articles, the major nature-based activities that people engaged in during the first lockdown in the spring of 2020. Keywords used in this study were grouped into six main topics: (1) COVID-19 pandemic; (2) nature-oriented activity focused on nature observation, identification of different taxa, or gardening; (3) mental well-being; (4) activities performed from a balcony, window, or in gardens; (5) entertainment; and (6) citizen science (see Table 1 for all keywords).

We also checked the total number of scientific studies from the pre-COVID-19 period that mentioned the same kind of activities that we found for the first lockdown period. We set the time period as 1930–2019 and compared their total number with the total number of papers about the same activities during COVID-19 until March 2023. We included all research papers but not letters that made claims without any data. The searched articles were required to be about the same kind of local-scale nature contact activities and refer to improvement of mental well-being.

Increase in global trends in interest in nature observation, gardening, and taxa identification during the first lockdown
We used the categorical cluster method, which was combined with big data from Google Trends (downloaded on 1 September 2020) and anomaly detection in Google Trends performed in R to identify trend anomalies globally in peoples' interests. We used this combination of methods to examine whether interest in nature-based activities that were mentioned in scientific and

Table 1. Keywords used in literature search.

Topics[†]	Keywords	Search source	Data collected
COVID-19 pandemic	"COVID-19," "lockdown"	Google Scholar/ Scopus	Records in number of papers, records in sample size (number of people), country
Observing nature/nature identification	"bird-watching," "bird identification," "butterfly watching," "butterfly identification," "plant identification," "gardening," "reptile watching," "amphibian watching," "citizen science," "visiting nature"	Google Scholar/ Scopus	Records in number of papers, records in sample size (number of people), country
Mental well-being[‡]	"mental health," "mental disorders," "depression," "anxiety," "mental well-being"	Google Scholar/ Scopus	Records in number of papers, records in sample size (number of people), country
Balcony/window/backyard observations or gardening	"window view," "balcony," "window," "backyard," "gardening"	Google Scholar/ Scopus	Records in number of papers, records in sample size (number of people), country
Re-appreciating activities of nature observation/identification in local scale	Meaning in the text after reading full text	Fully screened articles	Records in number of papers, records in sample size (number of people), country
Entertainment	"boredom," "relaxation," "new hobby," "happiness," also synonyms and similar meaning words in the text after reading the full text	Fully screened articles	Records in number of papers, records in sample size (number of people), country
Citizen science	"citizen science," "eBird," "iNaturalist," and similar meaning in the text after reading full text	Google Scholar/ Scopus/fully screened articles	Records in number of papers, records in sample size (number of people), country

[†] Keywords used in this study were grouped into six topics.
[‡]Google Scholar retrieved the highest number of records for the topic "mental health" in response to the listed keywords. Authors use many different synonyms or keywords in the body text when writing about mental health. Therefore, we chose to use "mental health" in searches, so that our methods would be more coherent, clear, and replicable for other scientists or readers.

nonscientific press articles increased during the first lockdown. Keywords linked with the main types of nature-oriented activities, as identified from press and scientific articles, and used according to the categorical clustering method were classified into the following six main categories: (1) global interest in bird-watching and bird identification combined with citizen science; (2) global interest in plant identification and gardening combined with citizen science; (3) global interest in butterfly watching, (4) local interest in early-spring (lockdown time), summer, or autumn flowering species that usually can be found in Central European (country: Poland) backyards; (5) global interest in traveling and social activities; and (6) global interest in nature areas and activities typically enjoyed during holidays and thus requiring traveling to land-spared nature reserves. The six categories were divided in 15 subcategories so that we could attach relevant words or phrases belonging to the same cluster and typically related to the activity (according to Google Trends and Google browser's automatic suggestions; e.g., people who searched for "bird-watching" typically also searched for "binoculars," "bird feeder," "bird nest," and "birdhouse").

The subcategories and keywords used for data collection about trends in society's interest in the studied topic from Google Trends are as follows.

1. Bird-watching: "binoculars," "bird feeder," "bird nest," "birdhouse," "bird-watching";
2. Bird identification: "bird app," "bird identification," "bird identification app," "bird identifier," "bird song app";
3. Bird-watching combined with citizen science: "bird guide," "bird identification," "eBird," "feeding birds," "iNaturalist";
4. Citizen science and bird-watching apps: "BirdNET," "BirdSong ID," "eBird," "iNaturalist," "Merlin Bird ID";
5. Gardening: "gardening," "planting," "seedling," "seeds," "soil";
6. Shopping for gardening: "garden shop," "plant buy," "plant ebay," "plant sell," "plant shop";
7. Plant identification apps: "FlowerChecker," "LeafSnap," "NatureGate," "Plantifier," "PlantSnap";
8. Citizen science and plant identification: "iNaturalist," "plant app," "plant check," "plant identification app," "plant identifier";
9. Flowers that were flowering in gardens during lockdown in Poland: "fiołek" (viola), "koniczyna" (shamrock), "mlecz" (dandelion), "pierwiosnek" (primose), "stokrotka" (daisy). They are typical early-spring flowers growing in the gardens in Central Europe. We had to be more specific in this search because there are no plant species blooming across the world at the same time. These plant species have well known biology; thus, we could easily interpret these results;
10. Flowers that were not flowering during lockdown in Poland: "chaber" (cornflower), "mak" (poppy), "nawłoć" (goldenrod), "róża" (rose), "rumianek" (chamomile). They are typical mid-summer flowering plants often planted in gardens;
11. Interest in traveling long distances and in social activities that involve many people: "airport," "bus," "café," "driving," "pub";

12. Single or mass commuting, and traveling: "bike," "boat," "car," "flight," "train";

13. Interest in distant places and activities for visiting natural areas: "forest," "nature park," "safari," "trekking," "trip";

14. Places and activities for holidays (typically located far away): "coral reef," "rainforest," "safari," "savanna," "snorkeling";

15. Butterfly watching: "butterfly watching," "butterfly identification," "butterfly app," "butterfly net," "butterfly guide";

In Google Trends, we set the following filters: global search, dates: July 2016–July 2020; language: English. We performed the search in July 2020. We chose Poland to collect trend data about internet search and phenology of flowering plants and search in Google. The flowering plant species were species that bloomed both during and outside the lockdown. We expected that during the first lockdown interest in early flowering species would increase but not species flowering later in the season (outside the lockdown time). Poland has 97% internet coverage, and Google browser is used by 97% of internet users; therefore, it is a typical European country with a similar level of internet access to other countries in Europe (Lenda et al. 2020).

Identifying possibilities of nature observation, gardening, and taxa identification in urban areas where green areas are large and far, or small and near

Using expert knowledge (eight experts; all authors of this study) and previously read articles, we identified and listed all possible advantages and disadvantages of concepts that allow contact with nature in urbanized landscape: (1) local-scale small green areas located among human settlements, and (2) large, distant nature-rich areas that require traveling.

Statistical analyses

All calculations were done in R (R Core Team 2021). We used anomaly detection analysis implemented in "anomalize" R package v. 0.2.2 (Dancho and Vaughan 2020). This analysis detects values that significantly ($P < 0.05$) deviate from other values in a time series. We also compared mean values of Google Trends index during the first lockdown with values of interest outside that period for group of keywords. We performed paired *t*-tests and computed 95% confidence intervals for each group of keywords. Non-overlapping confidence intervals and *t*-statistics were used to identify significant differences between mean values of Google Trends index of interest during the first lockdown and outside that period.

RESULTS

Identifying the most common types of activities related to nature observation, gardening, and taxa identification during the first lockdown

In Google Scholar, using our keywords, we found 4630 records that belonged to the category "nature observation, gardening, and taxa identification" and were related to the COVID-19 pandemic. We found articles about bird-watching, plant identification, and gardening. A total of 358 articles met the selection criteria of having in the text relevant keywords. After reading the full text of the 358 articles, we excluded those not related to the first lockdown, as well as articles mentioning lockdown, mental health, nature observation, taxa identification, and gardening but without methodology. Finally, the search resulted in 47 scientific articles from 28 countries and four global studies (a total sample of 114,466 people) describing people's contact with nature during the COVID-19 pandemic. All 37 articles that referred to the first lockdown described contact with nature that was near to home: from a window, balcony, or backyard/garden adjacent to private houses. Ten articles mentioned visiting nature areas, such as forests and parks, or allotments nearby for gardening during the first lockdown. Out of the 297 articles that we found on gardening, 34 met our criteria and described the popularity of gardening in backyards during the pandemic and suggested its usefulness in improving mental well-being. Of 61 articles found on bird-watching, five met our criteria and mentioned bird-watching as a popular activity during the pandemic that promoted mental well-being. Furthermore, four articles described the engagement of people in citizen science during the pandemic, and 47 articles suggested that contact with nature during the pandemic improved relaxation, reduced boredom and anxiety, and was helpful in improving mental well-being. We did not find scientific articles on other nature observation activities practiced during the first lockdown and their link with mental well-being.

We found 159 articles that mentioned associations between mental health and bird-watching from a window or in a backyard before the pandemic. Before the pandemic, as many as 53,102 articles mentioned that gardening improves mental well-being and recommended gardening nearby on a very local scale to help alleviate mental problems (Table 2).

In total, we found 36 English non-scientific press articles from seven countries that addressed nature contact during the first lockdown. Of these, 30 articles referred to nature contact in nearby natural areas, from a window, balcony, or backyard/garden adjacent to the house. The leading activities were bird-watching and gardening, followed by butterfly watching, almost all performed from home or the backyard. We found 16 press articles, from seven countries, on people's interest in bird-watching and bird identification during the first lockdown in 2020. We found 17 press articles, from five countries, on people's interest in gardening, two on butterfly watching or identification, two on citizen science and bird-watching, and two on citizen science and butterfly watching. All 36 articles linked contact with nature with mental well-being (Table 2). Articles suggested that such activities aid relaxation, reduce boredom, are enjoyable, can be a new hobby, and enable spending time with family members (Table 2). We did not find non-scientific press articles related to other activities associated with nature observation and mental well-being during the first lockdown.

A global increase in interest in nature observation/identification and gardening during the first lockdown

The global Google Trends data analysis showed spikes during the first lockdown in all six categories that were linked and described activities mentioned in press and scientific articles: bird-watching (paired *t*-test: $t = -2.914$, $df = 4$, $P = 0.046$); bird identification (paired *t*-test: $t = -2.753$, $df = 4$, $P = 0.051$); plant identification (paired *t*-test: $t = -5.647$, $df = 4$, $P = 0.005$); gardening (paired *t*-test: $t = -6.791$, $df = 4$, $P = 0.002$); applications used in bird (paired

Table 2. People's activities linked with nature observation, identification of species, or gardening, and their effect on mental well-being during the COVID-19 pandemic, that is, the first lockdown in spring 2020 and the preceding period. Data are from published press and scientific articles. The search was performed in February and March 2023.

Press articles related to the pandemic, first lockdown	N art.	N countries and list of countries
Total number of articles found	36	7 (US, UAE, UK, Australia, Canada, Poland, India)
Topics:		
Bird-watching from balcony/window/backyard	16	
Gardening in backyard	17	
Butterfly-watching in backyard	2	
Citizen science & bird-watching from balcony/window/backyard	2	
Linking the local contact with nature to mental well-being	36	
Articles about linking contact with nature and mental well-being from before the pandemic	14	
Topics:		
Gardening anywhere and mental well-being	13	
Gardening in local scale (backyard) and mental well-being	1	
Scientific articles related to the pandemic, first lockdown		
Total number of articles found	47	28 (Philippines, Canada, Italy, US, Ireland, Brazil, Spain, Japan, Colombia, UK, Bulgaria, Sweden, Czech Republic, Germany, France, Portugal, New Zealand, Mexico, Poland, Croatia, Israel, Italy, Lithuania, Slovenia, China, South Africa, Australia, Palestine)
Topics:		
Nature-based activities in near, local scale during 1st lockdown	37	
Nature-based activities after 1st lockdown, visiting distant green natural sites	10	
Gardening in near, local scale, alleviating mental well-being problems caused by the pandemic	34	
Gardening in distant place alleviating mental well-being problems caused by the pandemic	1	
Bird-watching (as a hobby) in near, local scale during 1st lockdown	5	
Linking contact with nature with mental well-being/relaxation/hobby and mental well-being	47	
Articles on contact with nature and mental well-being published before the pandemic		
Topics:		
Gardening in near, local scale (backyard) improves mental well-being	53,102	Worldwide
Bird-watching in local scale (backyard, balcony, window view) improves mental well-being	159	Worldwide

t-test: $t = -5.057$, $df = 4$, P = 0.007) or plant identification (paired *t*-test: $t = -2.560$, $df = 4$, P = 0.063); and data collection for citizen science (paired *t*-test: $t = -2.882$, $df = 4$, P = 0.045; Figs. 1–3). A search for Central Europe showed that interest in flowering species that bloom in the season when the first lockdown was set and that are typically found in backyards in Poland was extremely high during lockdown (paired *t*-test: $t = -2.779$, $df = 4$, P = 0.049; Fig. 3B). The data from Central Europe also showed that interest in plants that do not flower during that period did not change on average when compared to the trends before and after (paired *t*-test: $t = -1.552$, $df = 4$, P = 0.196; Fig. 3C). Global trends of interest in activities linked to traveling and social activities or places where they are performed (such as a pub or cafe), decreased drastically during the first lockdown (travelling: paired *t*-test: $t = -3.249$, $df = 4$, P = 0.031; social activities: paired *t*-test: $t = -4.591$, $df = 4$, P = 0.041; Fig. 4A, B). We found similar, but statistically non-significant, declines in global trends related to activities linked with holidays and visiting distant nature destinations, such as safari, trekking, coral reefs, and national park, during the first lockdown (places and activities for visiting distant nature: paired *t*-test: $t = -1.743$, $df = 4$, P = 0.156; places and activities for distant holidays: paired *t*-test: $t = 0.094$, $df = 4$, P = 0.929; Fig. 4C, D). However, all of these anomalies were transient and changed soon after the lockdown ceased.

Identifying possibilities of nature observation, gardening, or taxa identification in urban areas when nature areas are big and far, or small and near

We identified more advantages of the nearby and small nature areas for human well-being compared to far, even large, nature areas in an urbanized environment, both before and during the lockdown (Table 3). Moreover, we identified 18 types of daily life situations in which people cannot leave home easily and travel to experience nature (Table A1.1).

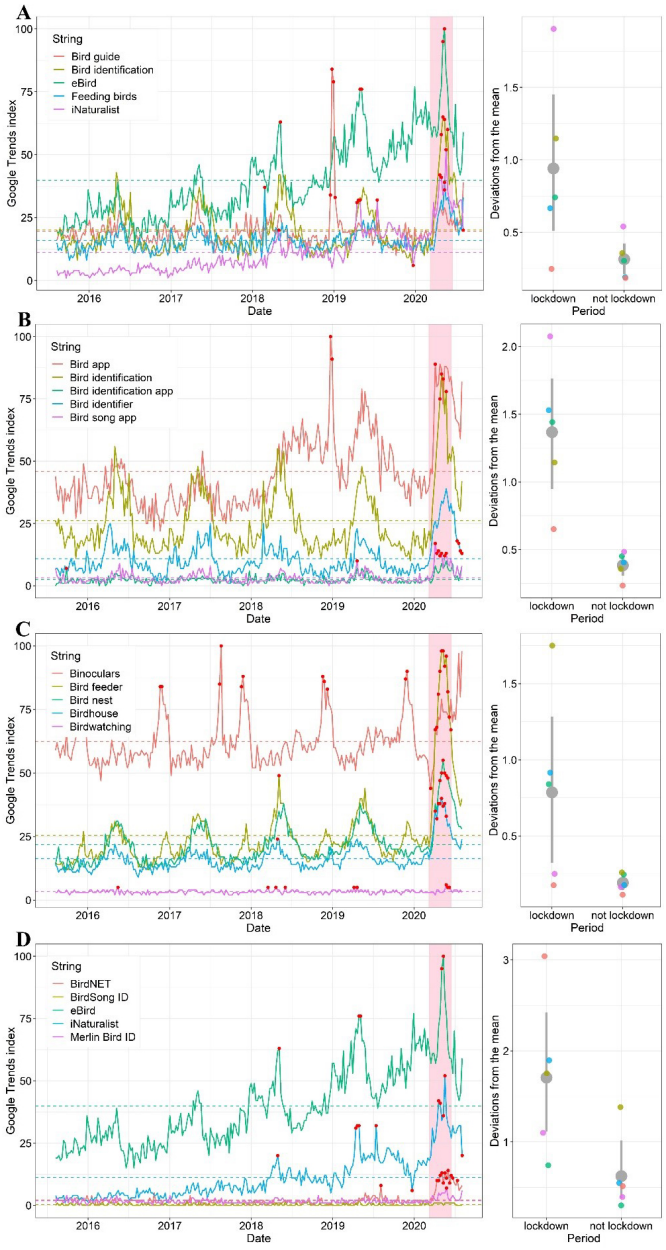
DISCUSSION

Our study shows that people became significantly more interested in observation and identification of wild nature and taxa found nearby at a very local scale during the first lockdown in the 2020. The media and scientific literature described contact with nature from a window, balcony, or in a backyard (i.e., at a local scale) as helpful in relaxation, stress relief, and reducing boredom caused by home confinement. However, mental stress caused by restrictions on going out and traveling could have been experienced by many people before and after the COVID-19 pandemic and lockdowns. There are many situations in which people cannot commute to nature-rich areas, and their contact with nature is limited to places within a few hundred meters. For example, 2.8 million people in the United Kingdom live more than a 10-min walk away from a public park, garden, or playing field (Fields in Trust 2019). Worldwide, as many as 75 million people use a wheelchair (World Health Organization 2011), and there are many other situations where mobility is highly restricted, and even reaching an area that is only 10 min away could be difficult (for examples of such situations in daily life see Table A1.1). Meantime, 82% of British adults reported that being in nature made them very happy during the pandemic, indicating high levels of nature connection among respondents (The People and Nature Survey for England 2022).

Gardening and bird-watching as recreation during lockdown

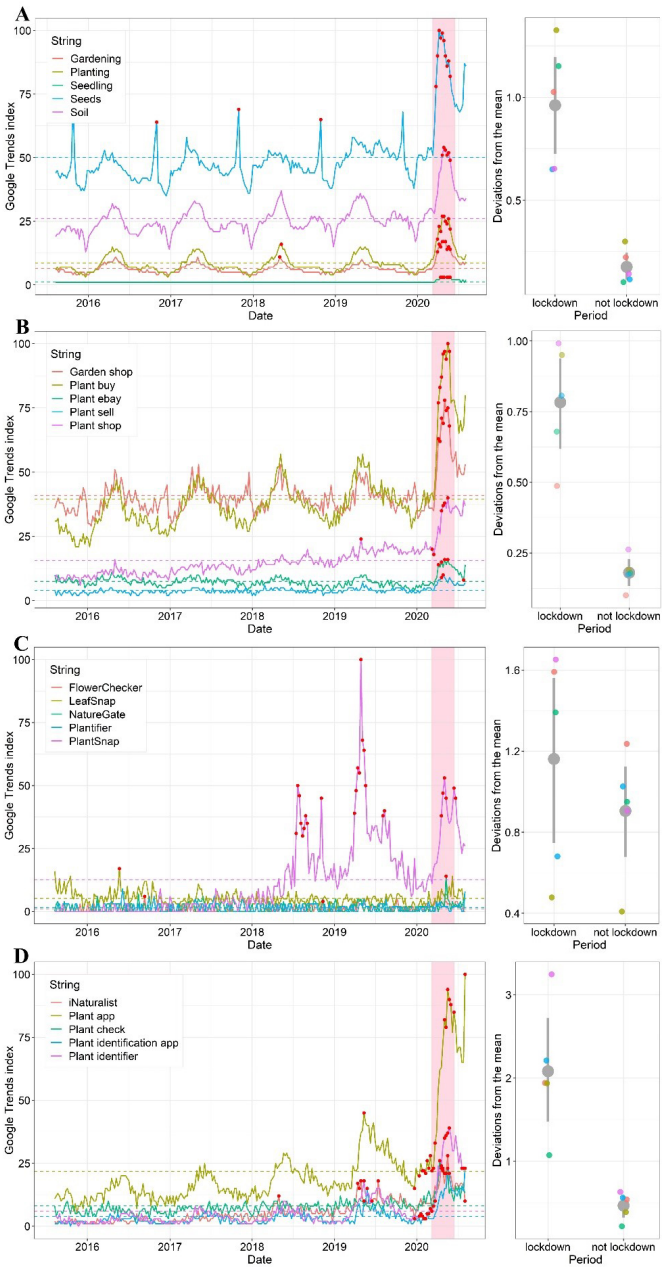
Gardening in backyards was the most frequently-mentioned activity during the first lockdown in both press articles and scientific literature, suggesting that a garden, regardless of its size, is an important site for relaxation and enjoyment that helps overcome stress and boredom.

Fig. 1. Interest (Google Trends index) in bird-watching and related activities (left panel). The vertical pink strip indicates the spring 2020 lockdown period and red dots indicate anomalies in time series. The mean value (with 95% confidence intervals) of Google Trends index for the lockdown period and the period before lockdown is shown on the right panel. A, interest in bird-watching. B, interest in bird identification. C, interest in bird-watching and citizen science. D, interest in bird-watching apps and citizen science apps. Data downloaded on 1 September 2020.



Articles discussing gardening concluded that it reduced mental health problems. Pre-COVID-19 pandemic studies had already showed that gardening reduces depression and stress because of contact with soil bacteria, which appears to aid in overcoming mental problems (Thompson 2018).

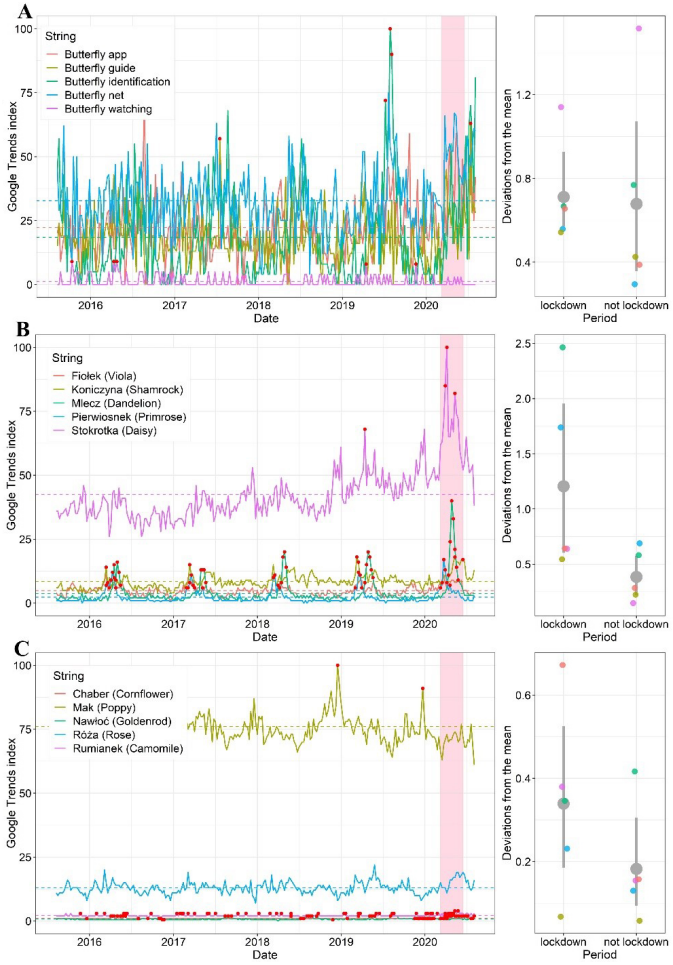
Fig. 2. Interest (Google Trends index) in gardening and plant identification. A, interest in gardening and related topics. B, interest in shopping for gardening. C, interest in apps for plant identification. D, citizen science and interest in plant identification apps. For explanation see Figure 1. Data downloaded on 1 September 2020.



Results from Google Trends also revealed increased global interest in gardening and related activities, such as plant identification and shopping for gardening activities. Results from Google Trends for Central Europe showed that, interestingly, people searched more

often for names of wild plants that would grow and bloom in gardens during the lockdown than for plants that bloom later in the season or do not typically grow in gardens. This suggests increased interest in planting species and also plant identification in gardens.

Fig. 3. Interest (Google Trends index) in butterfly watching and flowering plants. A, interest in butterfly watching and related activities. B, interest in flowers that were flowering in gardens during the lockdown in Poland. Flowering season of those plants is in spring (overlapping with the first lockdown). C, interest in flowers that were not flowering during the lockdown in Poland. For explanation see Figure 1. Data downloaded on 1 September 2020.



Gardening can help people during difficult times, but it requires owning a piece of land or having access to a communal garden, ideally close to one's home, a condition not often available in urban areas. For example, in the United Kingdom, one in eight British households has no garden (Office for National Statistics 2021) but of the seven who had access to a garden space, 79% spent time in it at least once a week and 34% said they did it for their health and mental well-being (The People and Nature Survey for England 2022). These results suggest that it would be beneficial to provide small pieces of land close to residential dwellings for hobby gardening, or increase green spaces in urban areas as a strategy for sustaining mental well-being of urban inhabitants (e.g., see Bartlomiejski and Kowalewski 2019).

Managed or unmanaged green spaces near buildings in urban areas provide a pleasant green view. Such green views are known to positively affect people's mental well-being (White et al. 2013).

Fig. 4. Interest (Google Trends index) in visiting nature and traveling. A, interest in traveling and social activities. B, interest in solo/private and group commuting and traveling. C, interest in places and activities for visiting nature (typically far from home). D, interest in places and activities for holidays (typically far from home). For explanation see Figure 1. Data downloaded on 1 September 2020.

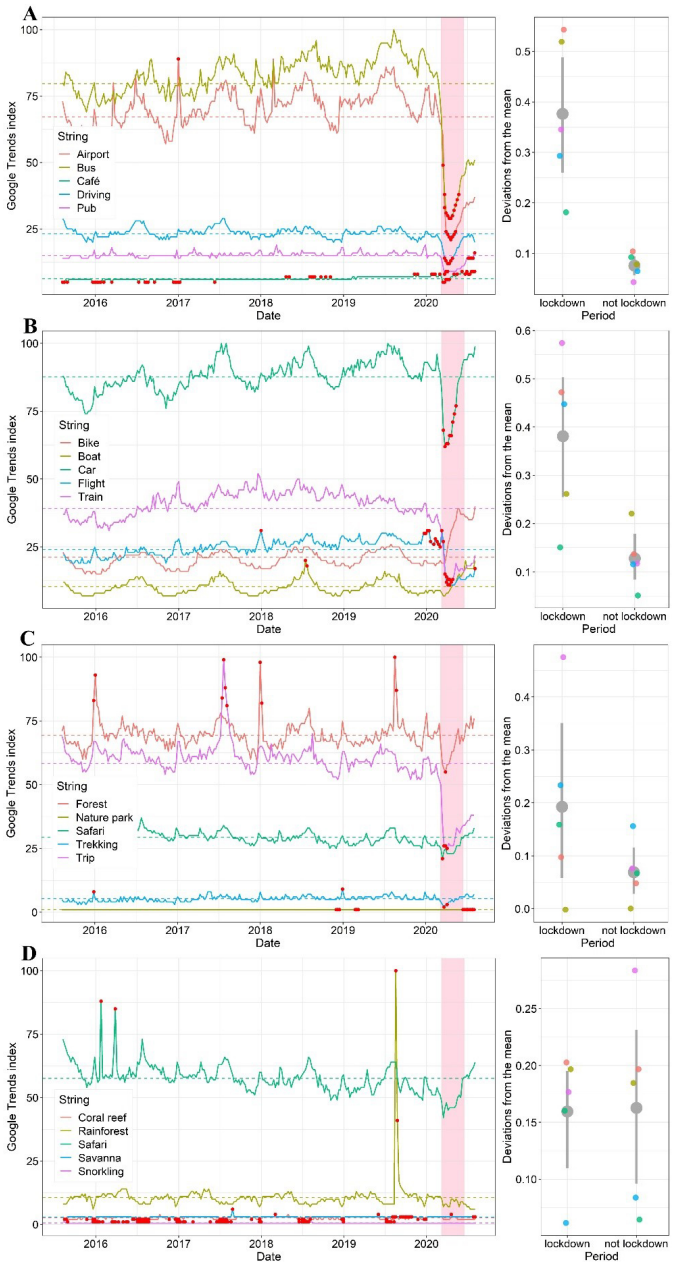


Table 3. Advantages (+) and disadvantages (-) of big and far and small and near-home nature areas that allow people to observe nature, identify species, or enjoy gardening in urban areas.

Big but far nature areas separated in urbanized environment (e.g., parks, city forests)	Small and near-home nature areas distributed among human settlements in an urbanized environment
Before lockdown:	Before lockdown:
+ visiting large spared nature areas (parks, city forests, lakes) with more plants and animals to observe or identify	+ nature observation, identification is effortless
+ visiting more diverse, spared habitats with more complex ecosystems and linkages between species or individuals	+ nature observation, identification performed from balcony/window/backyard
+ typically allows observation of organisms belonging to many groups characteristic of ecotones, and in the interior of forests.	+ gardening in backyard is easy
+ large space for gardening in allotments	+ nature observation, identification of species is easy during daily life, on the way to a shop/work/visiting doctor or a family member in need.
- usually needs commuting	+ easily accessible to elderly, expectant mothers
- visit needs planning	+ easily accessible to disabled people
- needs securing time	+ can be costless
- distant and large green areas in urban areas may be few, and thus overcrowded	+ nature observation, species identification from window, balcony, or backyard does not need special planning
- daily living in a monotonous landscape with extremely low biodiversity in massively urbanized areas	+ does not need traveling/commuting
- performed occasionally	+ green areas less overcrowded because they are near each building
- financial costs for traveling/commuting	- contact with less diverse habitats than in spared nature land, thus less species and individuals to observe
- impossible/difficult for disabled people	- nature observation; identification from window, balcony, or backyard is closer, but with lesser area than in spared land; ecosystems and interactions between species or individuals are less diverse
- impossible/difficult for elderly	
During lockdown:	During lockdown:
- Commute to spared nature areas, or visiting parks and forests is forbidden or impossible	+ nature observation and identification of species from window, balcony. or backyard still possible
- low possibility of observing and identifying species or gardening; not many green areas in urban environment	+ nature observation and identification of species from window, balcony or backyard effortless
- not possible to observe and identify species from house windows as many parts of urban areas do not have trees along streets, and look out to neighboring windows	+ perfect for disabled and elderly people
- observation from balcony/window/garden hardly possible	+ allows nature observations from home
- gardening impossible if places such as allotments are far	+ allows gardening
	+ observation of new wild species entering cities during lockdown is possible

In a 2018 study, the amount of green cover in the photographs of views captured from different floors were found to cause an important interaction effect on the frontal alpha and temporal beta brain oscillations in participants who viewed them (Olszewska-Guizzo et al. 2018). Brainwave patterns commonly associated with positive emotional states, motivation, and visual attention mechanisms increased with the extent of green cover in the view (Olszewska-Guizzo et al. 2018). Soga et al. (2021) showed that the frequency of visiting green spaces and the existence of green window views from within the home were associated with increased levels of self-esteem, life satisfaction, and subjective happiness and decreased levels of depression, anxiety, and loneliness during the pandemic in Tokyo.

Urban areas with grass, flowering herbaceous plants, trees, and flowering, fruiting shrubs attract insects and birds, and are abundant in plant species (Paker et al. 2014, Mata et al. 2017). Such small urban ecosystems may increase the opportunities to observe and identify wild organisms and even to observe interactions between species. Thus, urban planning approaches allowing sustainable urban development with small local green areas within human settlements would make it possible for people to observe nature and identify different species close to where they live. However, the literature often suggests that larger areas designated for nature conservation inside urbanized areas are also needed for effective protection of nature with greater biodiversity (Sushinsky et al. 2017, Ibáñez-Álamo 2020, Jokimäki et al. 2020).

Our search showed that both press and scientific articles reported increased bird-watching and identification during the first lockdown. Importantly, bird observations were noted to be coming from a window, balcony, or gardens, which is possible under strategies allowing close-to-home nature spaces in urban development. Global patterns observed in Google Trends confirmed that interest in bird-watching and bird species identification, performed from a window, in the backyard, or during bird feeding at home, increased during the lockdown. All the publications we found referred to bird-watching as an easily available form of recreation during home confinement (e.g., Oh et al. 2021b). Under urban development concepts in which buildings are densely distributed, and nature spaces are large but far away, bird-watching may be limited because birds looking for food and shelter would not be attracted to a place lacking trees. Murawiec and Tryjanowski (2020) also found that bird-watching had many positive effects on the well-being of psychiatrists during the COVID-19 pandemic. Moreover, they found that the notion of freedom associated with birds allows for a mental experience of breaking away from limitations and restrictions during isolation (see also Randler et al. 2021). Importantly, bird-watching from a window or backyard is inexpensive, easy, doable during lockdowns, and can also be enjoyed by disabled people, because the only equipment required are binoculars and bird guides or phone apps. Press articles from India reported butterfly watching as a strategy of coping with stress and boredom caused by the first lockdown; however, we did not find any scientific study

or trends in Google Trends to confirm it as a global trend. Butterfly watching is possible in migration seasons (Chowdhury et al. 2021) and areas rich in insects and flowering species, which is characteristic of tropical and subtropical climates but not of the temperate zone during winters.

Species identification and reporting observations in citizen science programs as recreation

Bird or plant identification requires special skills, guides, and technology. We identified a global trend on Google Trends indicating increased interest in species identification: people searched for "bird identification," "plant identification," and guides more often than before the lockdown. We also detected increased global interest in electronic applications for bird and plant identification, such as PlantNet and Merlin, during the lockdown. Importantly, we found that this pattern was followed by global trends in interest in citizen science applications, such as iNaturalist and eBird. This indicates an increased interest in citizen science and conducting useful observations according to a specific plan, with a real, scientific purpose. Scientific articles also described that during the COVID-19 pandemic participation of people in citizen science increased, but only on a very local scale, whereas engagement in activities requiring traveling outside of urbanized areas plummeted (Basile et al. 2021, Crimmins et al. 2021). Both press and scientific publications reveal that engagement in citizen science and observation from home or gardens or along the way to work are helpful in reducing boredom and are a kind of physical activity (Basile et al. 2021, Crimmins et al. 2021). Interestingly, people engaged in citizen science just for fun (Table 2), which suggests that this kind of activity can be promoted as inexpensive, easy entertainment: for example via city games, in the post-COVID era, in both near and far away nature spaces in the urban environment (Basile et al. 2021, Crimmins et al. 2021).

Study limitations and strengths

It is important to note that Google Trends data can sometimes yield inaccurate numbers because of homonyms. For example, the word "tiger" can refer to both an animal and a person, as well as the name of a beer brand. To address this, we carefully selected keywords for our research, ensuring they did not coincide with brand names or personal names when analyzing Google Trends results.

On the other hand, using Google Trends can help to avoid biases commonly found in traditional psychological questionnaires and experiments, as noted by Kemmelmeier (2016) and Lenda et al. (2020). This means that fluctuations in public interest can be accurately indicated by Google Trends data. Although experiments are often the preferred method, they are not always feasible, particularly in large-scale social sciences. In such cases, Google Trends provides valuable insights. Although the exact numbers obtained from internet trends may not be entirely accurate, the relative trends do reflect reality. This is because they are based on the raw numbers of searches people perform to find information or objects on the internet. People searching for names or items tend to be honest because they often feel anonymous and do not expect their activity to be monitored or recorded, effectively eliminating the investigator effect (Golder et al. 2017). In a 2011 study, it was discovered that an indicator for private consumption based on search query time series provided by Google Trends consistently outperformed survey-based indicators in forecasting experiments (Vosen and Schmidt 2011).

It is uncertain to what extent our findings from Google Trends can be generalized and it is impossible to link numbers to particular addresses or individual persons. However, Google Trends was demonstrated as useful in predicting economic indicators and financial markets (Choi and Varian 2012, Preis et al. 2013). Moreover, analysis of Google Trends data has proven valuable in detecting regional flu and influenza-like illness outbreaks within populations before conventional monitoring systems (Carneiro and Mylonakis 2009, Ginsberg et al. 2009).

We used our expert knowledge in the identification of advantages and disadvantages of nearby and far-from-home contact with nature during the first lockdown. We are aware that our classification could have been imperfect. However, as the authors of this study represent different countries, continents, cultures, age, and genders, we believe that we came adequately close to accuracy in listing advantages and disadvantages. Moreover, their knowledge was, of course, supported by information acquired from scientific publications reviewed in this study.

CONCLUSION

Our study shows that urban development should facilitate living conditions that support the mental well-being of inhabitants, such as proximity to and enjoyment of nature on a very local scale. Windows looking out at green areas and backyards that allow nature observation, identification of different species, and gardening are low-cost ways of deriving joy from nature. Such facilities may be helpful for people struggling with mental problems, especially when they have to spend most of their time at home. Urban development plans in which blocks of flats or houses fill every single free space, creating window views of neighboring residences instead of small green areas, may not be beneficial for people's mental well-being and should be avoided in long-term plans.

COVID-19 has substantially and simultaneously increased people's mental health problems globally, because the pandemic and the first lockdown happened roughly concurrently around the world. This generated global trends and allowed the scientific examination of the effects of social withdrawal and reduced physical activity on many aspects of human life. Our study emphasizes the importance of effortless contact with nature close to or from one's home, at a very local scale. Our findings urge that implications on mental health of citizens must be taken into account when designing urban residential spaces. Urban planners must do their best to design spaces in such a way that people have easy access to small green spaces near their homes or green views from windows. Incorporation of greenery in urban development projects should be an important part of policy design and decision making considering the significant benefits it bestows on residents' mental well-being, happiness, and by extension, on their physical health as well as work productivity.

Author Contributions:

M.L., M.J., P.S., H.P., E.N., P.T., D.M., and J.M.H.K. conceptualized the study and prepared the original draft; P.S. and M.L. conducted formal analysis and visualization; M.L. and P.S. provided resources, acquired funding, and administered the project; M.L., M.J., J.M.H.K., P.S., H.P, P.T., E.N., D.M. and H.-Y.L. reviewed and edited the manuscript.

Acknowledgments:

We are grateful to Prof. Richard Fuller for his comments. We are grateful to two anonymous referees for valuable critical points on earlier versions of the manuscript. This study was financed by "Sonata" project from Polish National Science Centre - project number 2021/43/D/NZ9/02990.

Data Availability:

All data are available in Dryad (https://doi.org/10.5061/dryad.fn2z34v1h).

LITERATURE CITED

Bartlomiejski, R., and M. Kowalewski. 2019. Polish urban allotment gardens as 'slow city' enclaves. Sustainability 11:3228. https://doi.org/10.3390/su11113228

Basile, M., L. F. Russo, V. G. Russo, A. Senese, and N. Bernardo. 2021. Birds seen and not seen during the COVID-19 pandemic: the impact of lockdown measures on citizen science bird observations. Biological Conservation 256:109079. https://doi.org/10.1016/j.biocon.2021.109079

Bertram, C., J. Meyerhoff, K. Rehdanz, and H. Wüstemann. 2017. Differences in the recreational value of urban parks between weekdays and weekends: a discrete choice analysis. Landscape and Urban Planning 159:5-14. https://doi.org/10.1016/j.landurbplan.2016.10.006

Bratman, G. N., C. B. Anderson, M. G. Berman, B. Cochran, S. de Vries, J. Flanders, C. Folke, H. Frumkin, J. J. Gross, T. Hartig, et al. 2019. Nature and mental health: an ecosystem service perspective. Science Advances 5:eaax0903. https://doi.org/10.1126/sciadv.aax0903

Brock, M., G. Perino, and R. Sugden. 2017. The warden attitude: an investigation of the value of interaction with everyday wildlife. Environmental and Resource Economics 67:127-155. https://doi.org/10.1007/s10640-015-9979-9

Brouzos, A., S. P. Vassilopoulos, V. C. Baourda, C. Tassi, V. Stavrou, K. Moschou, and K. O. Brouzou. 2023. "Staying Home - Feeling Positive": effectiveness of an on-line positive psychology group intervention during the COVID-19 pandemic. Current Psychology 42:2749-2761. https://doi.org/10.1007/s12144-021-01613-x

Carneiro, H. A., and E. Mylonakis. 2009. Google trends: a web-based tool for real-time surveillance of disease outbreaks. Clinical Infectious Diseases 49(10):1557-1564. https://doi.org/10.1086/630200

Choi, H. and H. Varian. 2012. Predicting the present with Google Trends. Economic Record 88:2-9. https://doi.org/10.1111/j.1475-4932.2012.00809.x

Chowdhury, S., R. A. Fuller, H. Dingle, J. W. Chapman, and M. P. Zalucki. 2021. Migration in butterflies: a global overview. Biological Reviews 96:1462-1483. https://doi.org/10.1111/brv.12714

Correia, R. A., R. Ladle, I. Jarić, A. C. M. Malhado, J. C. Mittermeier, U. Roll, A. Soriano-Redondo, D. Veríssimo, C. Fink, A. Hausmann, et al. 2021. Digital data sources and methods for conservation culturomics. Conservation Biology 35:398-411. https://doi.org/10.1111/cobi.13706

Cox, D. T. C., and K. J. Gaston. 2016. Urban bird feeding: connecting people with nature. PLoS ONE 11(7):e0158717. https://doi.org/10.1371/journal.pone.0158717

Cox, D. T. C., D. F. Shanahan, H. L. Hudson, K. E. Plummer, G. M. Siriwardena, R. A. Fuller, K. Anderson, S. Hancock, K. J. Gaston. 2017. Doses of neighborhood nature: the benefits for mental health of living with nature. BioScience 67(2):147-155. https://doi.org/10.1093/biosci/biw173

Crimmins, T. M., E. Posthumus, S. Schaffer, and K. L. Prudic. 2021. COVID-19 impacts on participation in large scale biodiversity-themed community science projects in the United States. Biological Conservation 256:109017. https://doi.org/10.1016/j.biocon.2021.109017

Cullen, W., G. Gulati, and B. D. Kelly. 2020. Mental health in the COVID-19 pandemic. QJM: An International Journal of Medicine 113(5):311-312. https://doi.org/10.1093/qjmed/hcaa110

Dancho, M., and V. Vaughan. 2020. anomalize: tidy anomaly detection. R package version 0.2.1. https://CRAN.R-project.org/package=anomalize

Douglas, I., M. Champion, J. Clancy, D. Haley, M. L. de Souza, K. Morrison, A. Scott, R. Scott, M. Stark, J. Tippett, et al. 2020. The COVID-19 pandemic: local to global implications as perceived by urban ecologists. Socio-Ecological Practice Research 2:217-228. https://doi.org/10.1007/s42532-020-00067-y

Dymnicki, A. B., and D. B. Henry. 2011. Use of clustering methods to understand more about the case. Methodological Innovations Online 6(2):6-26. https://doi.org/10.4256/mio.2010.0033

Evans, S., A. Mikocka-Walus, A. Klas, L. Olive, E. Sciberras, G. Karantzas, and E. M. Westrupp. 2020. From "It has stopped our lives" to "Spending more time together has strengthened bonds": the varied experiences of Australian families during COVID-19. Frontiers in Psychology 11:588667. https://doi.org/10.3389/fpsyg.2020.588667

Fields in Trust. 2019. Latest analysis of Great Britain's publicly accessible park and green space provision. https://www.fieldsintrust.org/green-space-index

Ginsberg, J., M. H. Mohebbi, R. S. Patel, L. Brammer, M. S. Smolinski, and L. Brilliant. 2009. Detecting influenza epidemics using search engine query data. Nature 457(7232):1012-1014. https://doi.org/10.1038/nature07634

Golder, S., S. Ahmed, G. Norman, and A. Booth. 2017. Attitudes toward the ethics of research using social media: a systematic review. Journal of Medical Internet Research 19(6):e195. https://doi.org/10.2196/jmir.7082

Green, R. E., S. J. Cornell, J. P. W. Scharlemann, and A. Balmford. 2005. Farming and the fate of wild nature. Science 307:550-555. https://doi.org/10.1126/science.1106049

Iannone, Jr., M. E. 2018. The impacts of green spaces on crime in New York City. Thesis, Fordham University, New York, New York, USA. https://fordham.bepress.com/environ_2015/60

Ibáñez-Álamo, J. D., F. Morelli, Y. Benedetti, E. Rubio, J. Jokimäki, T. Pérez-Contreras, P. Sprau, J. Suhonen, P. Tryjanowski, M.-L. Kaisanlahti-Jokimäki, et al. 2020. Biodiversity within the city: effects of land sharing and land sparing urban development on avian diversity. Science of the Total Environment 707:135477. https://doi.org/10.1016/j.scitotenv.2019.135477

Issa, T., M. Al Jaafari, A. S. Alqahtani, S. Alqahtani, T. Issa, L. Maketo, and S. Pervaiz. 2021. Benefits and challenges of social networking during COVID-19: personal perspective. International Journal of Web Based Communities 17(2):135-148. https://doi.org/10.1504/IJWBC.2021.114446

Jarić, I., R. A. Correia, B. W. Brook, J. C. Buettel, F. Courchamp, E. Di Minin, J. A. Firth, K. J. Gaston, P. Jepson, G. Kalinkat, et al. 2020. iEcology: harnessing large online resources to generate ecological insights. Trends in Ecology and Evolution 35 (7):630-639. https://doi.org/10.1016/j.tree.2020.03.003

Jokimäki, J, J. Suhonen, Y. Benedetti, M. Diaz, M.-L. Kaisanlahti-Jokimäki, F. Morelli, T. Pérez-Contreras, E. Rubio, P. Sprau, P. Tryjanowski, et al. 2020. Land-sharing vs. land-sparing urban development modulate predator-prey interactions in Europe. Ecological Applications 30(3):e02049. https://doi.org/10.1002/eap.2049

Jun, S.-P., H. S. Yoo, and S. Choi. 2018. Ten years of research change using Google Trends: from the perspective of big data utilizations and applications. Technological Forecasting and Social Change 130:69-87. https://doi.org/10.1016/j.techfore.2017.11.009

Kemmelmeier, M. 2016. Cultural differences in survey responding: issues and insights in the study of response biases. International Journal of Psychology 51(6):439-444. https://doi.org/10.1002/ijop.12386

Lenda, M., P. Skórka, B. Mazur, W. Sutherland, P. Tryjanowski, D. Moroń, E. Meijaard, H. P. Possingham, K. A. Wilson. 2020. Effects of amusing memes on concern for unappealing species. Conservation Biology 34(5):1200-1209. https://doi.org/10.1111/cobi.13523

Lippke, S., M. A. Fischer, and T. Ratz. 2021. Physical activity, loneliness, and meaning of friendship in young individuals - a mixed-methods investigation prior to and during the COVID-19 pandemic with three cross-sectional studies. Frontiers in Psychology 12: 617267. https://doi.org/10.3389/fpsyg.2021.617267

Marroquín, B., V. Vine, and R. Morgan. 2020. Mental health during the COVID-19 pandemic: effects of stay-at-home policies, social distancing behavior, and social resources. Psychiatry Research 293:113419. https://doi.org/10.1016/j.psychres.2020.113419

Mata, L., C. G. Threlfall, N. S. G. Williams, A. K. Hahs, M. Malipatil, N. E. Stork, and S. J. Livesley. 2017. Conserving herbivorous and predatory insects in urban green spaces. Scientific Reports 7:40970. https://doi.org/10.1038/srep40970

Millennium Ecosystem Assessment. 2005. Ecosystems and human well-being: synthesis. Island Press, Washington, D.C., USA.

Murawiec, S., and P. Tryjanowski. 2020. Psychiatra patrzy na ptaki w czasie pandemii COVID-19: obserwacje, introspekcje, interpretacje [A psychiatrist watches birds during the COVID-19 pandemic: observations, introspections, interpretations]. Psychiatria i Psychologia Kliniczna 20:94-97.

Murawiec, S., P. Tryjanowski, and A. Nita. 2021. An ornithological walk to improve the well-being of mental health professionals during the COVID-19 pandemic: a pilot study. Psychiatria 18(3):190-195. https://doi.org/10.5603/PSYCH.a2021.0024

Nghiem, L. T. P., S. K. Papworth, F. K. S. Lim, and L. R. Carrasco. 2016. Analysis of the capacity of Google Trends to measure interest in conservation topics and the role of online news. PLoS ONE 11:e0152802. https://doi.org/10.1371/journal.pone.0152802

Office for National Statistics. 2021. One in eight British households has no garden. https://www.ons.gov.uk/economy/environmentalaccounts/articles/oneineightbritishhouseholdshasnogarden/2020-05-14

Oh, R. R. Y., K. S. Fielding, C.-C. Chang, L. T. P. Nghiem, C. L. Y. Tan, S. A. Quazi, D. F. Shanahan, K. J. Gaston, R. L. Carrasco, R. A. Fuller. 2021a. Health and wellbeing benefits from nature experiences in tropical settings depend on strength of connection to nature. International Journal of Environmental Research and Public Health 18(19):10149. https://doi.org/10.3390/ijerph181910149

Oh, R. Y. R., K. S. Fielding, T. P. L. Nghiem, C.-C. Chang, D. F. Shanahan, K. J. Gaston, R. L. Carrasco, and R. A. Fuller. 2021b. Factors influencing nature interactions vary between cities and types of nature interactions. People and Nature 3:405-417. https://doi.org/10.1002/pan3.10181

Olszewska-Guizzo, A., N. Escoffier, J. Chan, and T. P Yok. 2018. Window view and the brain: effects of floor level and green cover on the alpha and beta rhythms in a passive exposure EEG experiment. International Journal of Environmental Research and Public Health 15(11):2358. https://doi.org/10.3390/ijerph15112358

Paker, Y., Y. Yom-Tov, T. Alon-Mozes, and A. Barnea. 2014. The effect of plant richness and urban garden structure on bird species richness, diversity and community structure. Landscape and Urban Planning 122:186-195. https://doi.org/10.1016/j.landurbplan.2013.10.005

Pfefferbaum, B., and C. S. North. 2020. Mental health and the COVID-19 pandemic. New England Journal of Medicine 383:510-512. https://doi.org/10.1056/NEJMp2008017

Preis, T., H. S. Moat, and H. E. Stanley. 2013. Quantifying trading behavior in financial markets using Google Trends. Scientific Reports 3:1684. https://doi.org/10.1038/srep01684

R Core Team. 2021. A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

Randler, C., N. Kalb, and P. Tryjanowski. 2021. Sentiment analysis of comments of American birders during two waves of the COVID-19 pandemic reveal more negative sentiments in the context of birding. International Journal of Environmental Research and Public Health 18(24):13142. https://doi.org/10.3390/ijerph182413142

Rezankova, H. 2014. Cluster analysis of economic data. Statistika 94:73-76.

Semeraro, T., A. Scarano, R. Buccolieri, A. Santino, and E. Aarrevaara. 2021. Planning of urban green spaces: an ecological perspective on human benefits. Land 10(2):105. https://doi.org/10.3390/land10020105

Soga, M., M. J. Evans, K. Tsuchiya, and Y. Fukano. 2021. A room with a green view: the importance of nearby nature for mental health during the COVID-19 pandemic. Ecological Applications 31(2):e02248. https://doi.org/10.1002/eap.2248

Soga, M., Y. Yamaura, S. Koike, and K. J. Gaston. 2014. Land sharing vs. land sparing: does the compact city reconcile urban development and biodiversity conservation? Journal of Applied Ecology 51:1378-1386. https://doi.org/10.1111/1365-2664.12280

Stone, M., and F. Blumberg. 2020. Effectiveness of categorical clustering as an encoding versus a retrieval strategy among preschoolers. Psychological Reports 123(6):2333-2352. https://doi.org/10.1177/0033294119860256

Sushinsky, J. R., J. R. Rhodes, D. F. Shanahan, H. P. Possingham, and R. A. Fuller. 2017. Maintaining experiences of nature as a city grows. Ecology and Society 22(3):22. https://doi.org/10.5751/ES-09454-220322

Thompson, R. 2018. Gardening for health: a regular dose of gardening. Clinical Medicine 18(3):201-205. https://doi.org/10.7861/clinmedicine.18-3-201

The People and Nature Survey for England. 2022. Data and publications from adults survey year 1 (April 2020 - March 2021) (Official Statistics) main findings. https://www.gov.uk/government/statistics/the-people-and-nature-survey-for-england-data-and-publications-from-adults-survey-year-1-april-2020-march-2021-official-statistics/the-people-and-nature-survey-for-england-data-and-publications-from-adults-survey-year-1-april-2020-march-2021-official-statistics-main-finding

Ugolini, F., L. Massetti, D. Pearlmutter, and G. Sanesi. 2021. Usage of urban green space and related feelings of deprivation during the COVID-19 lockdown: lessons learned from an Italian case study. Land Use Policy 105:105437. https://doi.org/10.1016/j.landusepol.2021.105437

Ulrich, R. S. 1984. View through a window may influence recovery from surgery. Science 224:420-421. https://doi.org/10.1126/science.6143402

Vlastakis, N., and R. N. Markellos. 2012. Information demand and stock market volatility. Journal of Banking and Finance 36 (6):1808-1821. https://doi.org/10.1016/j.jbankfin.2012.02.007

Vosen, S. and T. Schmidt. 2011. Forecasting private consumption: survey-based indicators vs. Google Trends. Journal of Forecasting 30(6):565-578. https://doi.org/10.1002/for.1213

White, M. P., I. Alcock, J. Grellier, B. W. Wheeler, T. Hartig, S. L. Warber, A. Bone, M. H. Depledge, and L. E. Fleming. 2019. Spending at least 120 minutes a week in nature is associated with good health and wellbeing. Scientific Reports 9:7730. https://doi.org/10.1038/s41598-019-44097-3

White, M. P., I. Alcock, B. W. Wheeler, and M. H. Depledge. 2013. Would you be happier living in a greener urban area? A fixed-effects analysis of panel data. Psychological Science 24 (6):920-928. https://doi.org/10.1177/0956797612464659

World Health Organization. 2011. World report on disability. https://apps.who.int/iris/bitstream/handle/10665/44575/9789240685215_eng.pdf?sequence=1&isAllowed=y

World Health Organization. 2020. COVID strategy update - 14 April 2020. https://www.who.int/publications/i/item/covid-19-strategy-update---14-april-2020

Zacher, H., and C. W. Rudolph. 2021. Individual differences and changes in subjective wellbeing during the early stages of the COVID-19 pandemic. American Psychologist 76(1):50-62. https://doi.org/10.1037/amp0000702

Appendix 1. Table 1 and database with articles

Please click here to download file 'appendix1.xlsx'.