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Self-reported participation in outdoor and nature-based recreation before and during the COVID-19 pandemic supports psychological health and well-being

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ARTICLE INFO
Keywords:
Subjective Well-being
COVID-19
Resilience
Nature-based Recreation
Outdoor Recreation

ABSTRACT
Restrictions associated with the COVID-19 pandemic significantly altered daily lives and affected human health and well-being. Outdoor and nature-based activities could potentially mitigate some of these negative impacts. To assess the impact of the COVID-19 pandemic on outdoor recreation and subjective well-being, we combined two samples of U.S. adults collected from April 30th - June 15th, 2020 and from August 7th - August 26th, 2020 (total n = 2178) using Qualtrics XM. During the pandemic, participation in outdoor activities declined by 35%, participation in nature-based activities declined by 33%, and subjective well-being declined by 24%. Participation in outdoor activities and nature activities prior to the pandemic and during the pandemic predicted smaller declines in subjective well-being. Results highlight the importance of outdoor recreation for building resilience to changes in subjective well-being before and during global crises like the COVID-19 pandemic.

1. Introduction

Large-scale global crises such as climate change, land-use change, and pandemics threaten the health and well-being of individuals worldwide (Myers & Patz, 2009). However, interventions that increase individuals’ psychological resilience in times of crisis may reduce the negative mental health impacts of these events (Hayes et al., 2018; Kuntz, 2021). In this context, resilience is defined as the ability to resist changes in (or recover) psychological health during times of adversity (Herrman et al., 2011). One important mental health construct linked to resilience is subjective well-being (SWB; Bajaj & Pande, 2016; Tomyn & Weinberg, 2018). SWB is defined as “how people experience and evaluate their lives and specific domains and activities in their lives” (National Research Council, 2013, pg. 1) and consists of high positive affect, low negative affect, and satisfaction with life (Diener, 2000). SWB, often equated with happiness, is the primary measure of hedonic well-being (Ryan and Deci, 2001) and is often used as a measure of mental health (Keyes, 2005, 2006). Thus, examining factors that influence changes in SWB can improve understanding of how to build resilience in times of crisis. The need for such investigations was particularly evident during the COVID-19 pandemic, which transformed the daily lives of individuals worldwide (Kuntz, 2021).

Although restrictions associated with the COVID-19 pandemic were crucial for slowing the spread of the virus and preventing deaths (Wilder-Smith & Freedman, 2020), they have also been linked to negative mental and physical health risks (Boden et al., 2021; Rossi et al., 2020; Woods et al., 2020). Some common restrictions mandated or encouraged during the pandemic included social isolation, quarantine, travel restrictions, and closures of businesses – measures which have been shown to negatively impact mental health (Holman et al., 2020; Jenkins et al., 2021; Rossi et al., 2020). For example, a web-based survey in Italy from March 27th through April 6th, 2020 found that experiences related to quarantine restrictions were associated with post-traumatic stress symptoms and anxiety (Rossi et al., 2020). Similarly, a nationally representative sample of Canadians collected from May 2020 found that approximately 38% of respondents reported a decline in their mental health.
health since the beginning of the pandemic, citing social isolation as a contributing factor (Jenkins et al., 2021). A nationally representative survey of Americans collected from March 18th to April 18th, 2020 found that, among others, secondary stressors such as personal losses and social distancing influenced increases in acute stress and depression (Holman et al., 2020). These examples highlight the pervasive mental health impacts of COVID-19 restrictions that occurred on a global scale (Boden et al., 2021; Pfefferbaum & North, 2020).

Participation in activities that traditionally support mental well-being may render people more resilient to negative impacts on SWB during stressful events. Many practices ranging from social activities (Nitschke et al., 2021; Ozbay et al., 2007) to exercise (Southwick et al., 2005) can make people more resilient to stressors, but such activities often increase risk of disease transmission and are restricted during pandemics (Nyenhuis et al., 2020; Vang et al., 2021). Recreational activities that take place outdoors, however, have been identified as relatively safe (Centers for Disease Control, 2021) and have been shown to support improved mental health during the COVID-19 pandemic (Jackson et al., 2021; Larson et al., 2021). Outdoor activities also facilitate opportunities for social interaction, which play an important role in maintaining an individual’s mental well-being (Brown et al., 2021). In a sample of adolescents, those who participated in outdoor play and nature activities during the pandemic experienced a smaller decline in subjective well-being (Jackson et al., 2021). In other studies, adults who increased their participation in outdoor activities during the pandemic reported better mental health than those who decreased their participation in outdoor activities (Cindrich et al., 2021; Larson et al., 2022). These findings suggest the contribution of public parks to psychological well-being (Larson et al., 2016) may be magnified during pandemics.

One way participation in outdoor activities may improve mental well-being is through exposure to nature. Spending time in nature provides a range of health and well-being benefits including relief from stress (Hartig et al., 2003), while also alleviating negative health outcomes associated with stress (Van den Berg et al., 2010). One 4-year cohort study revealed that those who lived in areas with increases in urban greening were less likely to experience feelings of loneliness during the study period (Astell-Burt et al., 2022). Within the context of COVID-19, individuals in several European countries who did not have access to an outdoor space or access to view a green space during the lockdown period had higher odds of developing symptoms of clinical depression (Pouso et al., 2021). Those in France and Germany who had higher nature exposure experienced greater psychological health during the lockdown period (Javelle et al., 2021). These examples highlight the potential of parks, green space, and nature-based interventions to help reduce the mental health impacts of crises like the COVID-19 pandemic (Labib et al., 2022; Xie et al., 2020; Venter et al., 2020) and they underscore the need to explore how frequency of participation in nature-based activity influences psychological resilience.

Participation in outdoor activities also provides opportunities for physical activity, which plays an important role in maintaining both physical and mental health (Bertheussen et al., 2011). Previous research demonstrates that lower levels of physical activity are linked to lower life satisfaction (Maher et al., 2015), while an increase in the frequency and duration of moderate physical activity experienced subjective well-being (Wicker & Frick, 2015). A cross-sectional study of 1.2 million individuals within the U.S. between 2011 and 2015 found that all types of exercise (e.g., group sports, cycling, gym activities, etc) were associated with fewer self-reported poor mental health days within the past month (Chekroud et al., 2018). Furthermore, research investigating the link between physical activity and exposure to nature demonstrates that engaging in physical activity in natural spaces yields greater health and well-being benefits than physical activity alone (Mitchell, 2013), highlighting the potential fitness benefits of nature-based recreation. Physical activity has also been linked to mental health during the pandemic, as evidenced by a study conducted in Italy from April 2020 that found that those who reduced their participation in physical activity experienced a decrease in their psychological health and well-being (Maugeri et al., 2020). Similarly, those who spent more time exercising were more psychologically resilient during the pandemic (Killgore et al., 2020), and physical inactivity was associated with more severe COVID-19 outcomes such as hospitalization or death (Sallis et al., 2021). These linkages between mental health and physical activity highlight the potential dividends of promoting outdoor activities during the pandemic for both psychological and physical health across diverse populations.

The COVID-19 pandemic has also fueled health equity concerns, as negative impacts have not been distributed equally across all segments of society. For instance, Black and Latino populations in the U.S. bore a disproportionate burden from COVID-19 including higher mortality, prevalence of infection, and mental health risks (Fortuna et al., 2020; Hooper et al., 2020) and were significantly more likely to report having seriously considered suicide within the past 30 days (Czeisler et al., 2020). Similarly, a study of U.S. college students showed that certain marginalized groups (e.g., women, Asians) were more likely report emotional distress during the pandemic (Brown et al., 2021). Such patterns were not limited to the U.S.; a longitudinal observational study in England found that symptoms of anxiety and depression were high at the beginning of the lockdown period but recovered over the span of 20 weeks for all individuals sampled (Fancourt et al., 2021). However, being a woman, having lower educational attainment, and having lower income were among risk factors for higher levels of depression and anxiety both at the beginning of the lockdown and at the end of the 20-week period. Individuals living in urban areas may also be disproportionately impacted by the pandemic as they have a greater risk of viral infection, as well as reduced access to nearby nature, potentially limiting opportunities to safely engage in activities that provide physical activity and social interaction (Rigolon et al., 2018; Samuelsson et al., 2020). Additionally, the greater density of people living in urban areas and the limited availability of nearby nature may further limit outdoor activity participation due to overcrowding in existing recreational green spaces (Freeman & Eykelbosh, 2020). Further, those who felt deprived of nature during the COVID-19 pandemic were at a higher risk of reduced well-being, highlighting the importance of green spaces along the urban gradient (Tomasso et al., 2021). These challenges related to urban greenspace use and access during the pandemic may be particularly prominent in socially vulnerable communities (Larson et al., 2021). Such disparate risks to mental and physical health underscore the urgent need to explore ways to mitigate impacts of the COVID-19 pandemic that are accessible to all populations.

Our study builds upon prior research examining the influence of outdoor activities on well-being during the COVID-19 pandemic (Jackson et al., 2021; Cindrich et al., 2021). Jackson et al. (2021) examined this relationship for children, but not for adults. Cindrich et al. (2021) examined the relationship between time spent outdoors and psychological health, but did not investigate the types of outdoor and nature-based activities that contribute to this relationship. This study thus represents a novel contribution to the rapidly growing literature on links between nature and health during the pandemic (Labib et al., 2022), as it examined how both the type and frequency of several outdoor activities influenced subjective well-being for a sample of adults within the United States. We also accounted for the impacts of several demographic variables associated with the impacts of COVID-19 including ethnicity, gender, and urban or rural area of residence (Czeisler et al., 2020; Gausman & Langer, 2020; Peters, 2020). To better understand the impact of outdoor and nature-based activities on subjective well-being through different phases of the pandemic, we tested several hypotheses:

H1: Subjective well-being decreased due to the COVID-19 pandemic;
H2: Participation in outdoor recreation decreased due to the COVID-19 pandemic;
H3: Those who engaged in more outdoor recreation prior to the COVID-19 pandemic experienced a smaller decline in SWB regardless of their demographic background;
H4: Those who maintained a higher level of participation in outdoor recreation during the pandemic experienced a smaller decline in SWB regardless of their demographic background.

2. Materials and Methods

2.1. Data Collection

Our dataset consisted of two samples of U.S. adults collected using the online survey software Qualtrics XM. A Qualtrics XM online survey panel is composed of respondents who sign up to participate in online surveys through the Qualtrics website. Researchers set certain criteria for a sample (in our case, a representative sample of U.S. adults) and Qualtrics invites respondents to participate who meet the criteria. Qualtrics continues to collect data until quotas are filled. The panels for both samples drew from a national pool (50 states and Puerto Rico) with demographic quotas for regions of the United States (South, West, Midwest, Northeast), race/ethnicity (White, Hispanic, Black, Asian), and age (18-34, 35-54, 55+). These demographic quotas were meant to approximate a representative sample of U.S. citizens. Prior research shows that a sample of n = 500 provides a representation of a national population with a confidence interval of +/- 5% (Vaske, 2019). The first sample, hereafter the ‘June sample’, was collected from April 30th - June 15th 2020. The second sample, hereafter the ‘August Sample’ was collected from August 7th - August 26th, 2020. These two datasets were merged in Microsoft Excel prior to analysis. The final sample consisted of 2,178 observations. Both data collections were approved by the NC State Institutional Review Board (April 30th - June 15th data collection: IRB #16606; August 7th - 26th data collection: IRB #21226).

2.2. Survey Instrument

We adopted several scales previously established and validated in literature for this study. For each of these questions, we asked respondents to self-report about their experiences both before and during the COVID-19 pandemic, leading to a ‘before COVID-19’ and ‘during COVID-19’ variable for each construct. The scales measuring frequency of participation in nature activities and outdoor activities prior to the pandemic and during the pandemic were adapted from Jackson et al. (2021). For the outdoor and nature activity items, we asked “How often did you participate in the following activities this time last year and now, after you have been asked to practice social distancing because of the coronavirus outbreak?” for several outdoor activities (playing sports outside, bicycling outside, going for walks or runs outside, swimming outside) and several nature-based activities (wildlife viewing, camping, hiking, paddling (canoeing, kayaking), hunting, and fishing). Participants provided two responses (one for “this time last year” and one for “now”) with the options: 0 = ‘never’, 1 = ‘some of the time’, 2 = ‘most of the time’, and 3 = ‘all of the time’. Although many self-reported measures of mental health exist, we deemed the WHO’s SWB scale most appropriate for our research context for several reasons. While certain scales (e.g., The Kessler-10 scale) emphasize negative symptoms such as anxiety and depression (Kessler et al., 2003), we wanted to focus on presence of something positive rather than the absence of something negative (Magyar & Keynes, 2019).

Scales that focus on life satisfaction integrate factors such as life achievement that stray away from our focus on core affect and emotion (International Wellbeing Group, 2013; Cummins et al., 2009; Pavot & Diener, 2009). Several focused scales that effectively measure the same construct (e.g., The Warwick-Edinburgh Mental Well-Being Scale, WEMWBS) use many more items, increasing potential survey fatigue in participants (Tennant et al., 2007). Thus, our measure of SWB was simple, easy-to-implement, and effectively captured affective components of wellbeing likely to be impacted by the COVID-19 pandemic (Topp et al., 2015; Jackson et al., 2021).

We also measured several demographic variables. For gender, we asked “What is your gender?” with the options ‘male’, ‘female’, or ‘other’. For race, we asked respondents “What race/ethnicity do you identify as?” with the options ‘White or Caucasian, non-Hispanic’, ‘African American, non-Hispanic’, ‘Asian or Pacific Islander’, ‘Native American’, ‘Hispanic’, ‘Two or more of the above’, and ‘Other’. For age, we asked “What is your age range?” with the options ’18 to 24 years old’, ‘25 to 34 years old’, ‘35 to 44 years old’, ‘45 to 54 years old’, ‘55 to 64 years old’, and ‘Age 65 or older’. For the variable ‘area’, we asked “What best describes the place where you live now?” with options ‘Rural area’, ‘Small city or town’, ‘Suburb near a large city’, and ‘Large city’.

2.3. Data Analysis

2.3.1. Data Preparation

In both the June and August samples, there were no missing data to account for, as Qualtrics employed forced validation. Listwise deletion was used in order to remove any responses containing straight-line replies (answering the same for all questions) or nonsensical text replies (related to open text questions), resulting in the removal of 257 responses from the June sample for a final sample of 624, and removal of 88 from the August sample for a final sample of 1554.

All data preparation occurred in SPSSv26. Merging the June and August datasets required several coding changes. First, the question “How often did you participate in the following activities this time last year and now, after you have been asked to practice social distancing because of the coronavirus outbreak?” had three options in June and four options in August. The ‘often’ and ‘very often’ categories were collapsed on the August data. The ‘age’ variable was continuous in the August dataset and had to be recoded into the categories present in the June dataset. For the ‘gender’ variable, the additional categories in the June dataset of 3 = ‘non-binary’, 4 = ‘1 identify another way’, were recoded into 3 = ‘other’ to match the August gender variable. Ultimately, the ‘other’ category in the gender variable comprised less than 0.3% of our sample, and was not sufficient to analyze. The ‘area’ variable was also distinct between the two datasets and required recoding, and the August dataset was recoded to match the June dataset. Specifically, 1 = ‘A large city or urban area (more than 250,000 people) was recoded to 4 = ‘Large city’, 2 = ‘A medium-sized city (50,000-250,000 people)’ was recoded to 3 = ‘suburb near a large city’, 3 = ‘A small city (10,000 to 50,000 people)’ was recoded to 2 = ‘small city or town’, and 4 = ‘A small town or rural area (10,000 people or less)’ was recoded to 1 = ‘Rural area’.

All subsequent data manipulation and analyses were run in the statistical software R (R Core Team, 2021). In the final dataset, we created the ‘region’ variable by recoding the ‘state’ (all 50 U.S. states) variable into one of four U.S. regions (Northeast, South, West, Midwest) with
2.3.2. Exploratory Factor Analysis of Activity Items and Scale Reliabilities

We employed an exploratory factor analysis (principal components analysis with Varimax rotation) to investigate the dimensionality of the SWB scale adapted from Jackson et al. (2021) (Table 1). This was done to confirm that the dimensionality of each scale was not different between a sample of children used in Jackson et al. (2021) and our sample of adults. Our analysis supported a unidimensional factor structure for the SWB scale, as indicated by a single Eigenvalue greater than one that was able to account for 53% of the variance. The SWB scale also exhibited high internal consistency (α = 0.91) and convergent validity (all items exhibited factor loadings > 0.50) (Hair et al., 2014). We also employed an exploratory factor analysis to investigate possible dimensions within the group of outdoor and nature activities adapted from Jackson et al. (2021) (Table 2). The analysis supported a two-factor structure, as indicated by two Eigenvalues greater than one that were able to explain 55% of the variance. The factors were outdoor activities (4 items, α = 0.79) and nature-based activities (6 items, α = 0.89). Each factor exhibited appropriate convergent validity (factor loadings > 0.50 for items loading on each factor). For the purpose of brevity, we only displayed EFAs for the ‘pre COVID-19’ scales in Table 2, but the ‘during COVID-19’ scales produced similar results.

Composite index scores for scales were generated by summing and averaging each of these factors for both the ‘Pre COVID-19’ and ‘During COVID-19’ items. For example, we added the scores of each item on the SWB scale and divided by the total number of items to create a composite index score for each individual. This led to the creation of the variables ‘Pre COVID-19 SWB,’ ‘During COVID-19 SWB,’ ‘Pre COVID-19 participation in outdoor activities,’ ‘During COVID-19 participation in outdoor activities,’ ‘Pre COVID-19 participation in nature-based activities,’ and ‘During COVID-19 participation in nature-based activities’. To create the ‘Change in SWB,’ ‘Change in nature-based activity participation during COVID-19,’ and ‘Change in outdoor activity participation during COVID-19’ variables, we subtracted each of the ‘Pre COVID-19’ variables from the ‘During COVID-19’ variables (post - pre). Although it is difficult to discern absolute rates of activity participation based on composite index scores, the means denoting relative participation rates provided a useful basis of comparison for our models.

2.3.3. Hypothesis Testing

Prior to hypothesis testing, we checked to confirm assumptions of normality were not violated so that parametric data analysis procedures could be applied. Normality tests showed that skewness scores for all major study variables (SWB pre, post, and change; outdoor recreation pre, post, and change; nature-based recreation pre, post, and change) fell within the acceptable range of -2 to 2, while kurtosis values ranged from 2.10 to 3.98 (slightly outside the preferred range; George & Mallery, 2010). However, histograms of the subjective well-being scale items and combined index scores did not indicate a major departure from normality (see supplementary materials). Although ordinal or interval scale data such as those collected in this study are not always conducive to parametric analysis, previous research indicates parametric tests can be robust even when applied to ordinal data that is non-normal or skewed (Grech & Calleja, 2018; Norman et al., 2010). This is true especially when an aggregate index score is calculated from multiple scale items prior to analysis (Ilurbe, 2015; Carifio & Perla, 2007), mirroring our approach in this study.

To investigate hypotheses 1-2, we conducted paired sample t-tests to examine differences in SWB before and during COVID-19 (H1) and differences in outdoor and nature-based recreation participation before and during COVID-19 (H2). We employed the Holm-Bonferroni correction to account for family-wise error rate associated with multiple tests of significance (Holm, 1979). To investigate hypotheses 3-4, we used a multiple linear regression model to examine the influence of several variables on change in SWB during (pre). We regressed ‘change in SWB’ on ‘Pre COVID-19 participation in outdoor activities,’ ‘Pre COVID-19 participation in nature-based activities,’ ‘Change in nature-based activity participation during COVID-19,’ and ‘Change in outdoor activity participation during COVID-19’ variables. We also included SWB pre prior to COVID-19 to account for a potential ‘ceiling effect’ where those who have lower initial SWB have less room to decline in SWB compared to those with higher initial SWB (Dalecki & Willits, 1991). Additionally, we controlled for age (with ‘aged 35-44’ as the reference group), gender (where ‘male’ was the reference group), race (with ‘white’ as the reference group), area of residence (with ‘a large city’ as the reference group), and geographic location (with ‘south’ as the reference group).

Each reference group was selected based on which category had the largest sample size. To control for differences between the two time periods (i.e., the two samples), we included a binary variable where 0 = ‘June sample’ and 1 = ‘August sample’. For demographic variables that

### Table 2

| Item | Activity means | Nature-based factor | Outdoor activity factor |
|------|----------------|---------------------|------------------------|
| Nature-based Activity Scale | 0.76 | 0.74 | 0.31 |
| Paddling (canoeing, kayaking) | 0.59 | 0.72 | 0.35 |
| Hunting | 0.50 | 0.78 | 0.24 |
| Fishing | 0.79 | 0.69 | 0.32 |
| Wildlife viewing | 0.93 | 0.69 | 0.30 |
| Hiking | 0.93 | 0.60 | 0.38 |
| Outdoor Activity Scale | 1.19 | 0.72 | 0.50 |
| Bicycling outside | 1.02 | 0.57 | 0.72 |
| Going for walks or runs outside | 1.55 | 0.15 | 0.50 |
| Playing sports outside | 1.11 | 0.20 | 0.70 |
| Swimming outside | 1.07 | 0.40* | 0.59 |
| Eigenvalues | 5.30 | 1.07 | 33% |
| % of variance explained | 33% | 22% | 0.89 | 0.79 |
| Cronbach’s alpha | | | |

Response scale items included: Never = 0, Every now and then = 1, Often = 2. Analyzed using Principal Components Analysis with Varimax rotation. Exploratory factor analysis on the ‘During COVID-19’ scales produced similar results. *Cross loaded item.

### Table 1

| Item | SWB means | SWB factor loadings |
|------|-----------|---------------------|
| SWB index score | 2.05 | 0.74 |
| Cheerful and in good spirits | 2.07 | 0.74 |
| Calm and relaxed | 1.98 | 0.78 |
| Active and full of energy | 2.13 | 0.59 |
| Interested and curious about the world around me | 2.01 | 0.79 |
| Eigenvalue | 2.57 | 53% |
| % of variance explained | 0.91 |

Response scale items included: At no time=0, Some of the time=1, Most of the time=2. All of the time=3. Analyzed using Principal Components Analysis with Varimax rotation. Exploratory factor analysis on the ‘During COVID-19’ scales produced similar results.
were significant correlates of SWB in the regression model, we conducted additional follow-up tests (e.g., t-test, ANOVA) to explore group differences in changes in outdoor activity and nature-based activity participation.

3. Results

3.1. Sample

Our sample (n = 2178) had a slightly larger proportion of women (53.4%) than men (46.3%). The proportion of races represented closely aligned with those in the general population (U.S. Census Bureau, 2019). The largest age category was aged 35-44 (30%), the largest community type was ‘large city’ (34.5%), and the largest region category was ‘south’ (37.9%; Table 3).

3.2. Subjective Well-Being Scores

We found support for H1, as SWB scores declined by 24% during the pandemic (t[2177] = 29.28, p < 0.001; Table 4). Overall, 59% of respondents reported a decrease in SWB, 28% reported no change in SWB, and 13% reported an increase in SWB.

3.3. Outdoor and Nature-Based Activity Scores

We found support for H2, as there was a 35% decline in outdoor activities (t[2177] = 29.99, p < 0.001; Table 4, Fig. 1) and a 33% decline in nature-based activities (t[2177] = 24.30, p < 0.001; Table 4, Fig. 1) during the pandemic. Overall, 57% of respondents reported a decrease in outdoor activity, 31% of respondents reported no change, and 11% of respondents reported an increase. Half (50%) of respondents reported a decrease in nature activity, 40% reported no change, and 10% of respondents reported an increase.

Table 3
Sample demographics among U.S. respondents (n = 2178).

| Variable       | N   | %    |
|----------------|-----|------|
| Gender         |     |      |
| Male           | 1009| 46.3%|
| Female         | 1162| 53.4%|
| Other          | 7   | 0.3% |
| Race           |     |      |
| White          | 1315| 60.4%|
| Black          | 284 | 13.0%|
| Hispanic       | 373 | 17.1%|
| Asian/Pacific Islander | 138 | 6.3% |
| Native American| 15  | 0.7% |
| Other          | 24  | 1.1% |
| Two or more races | 23  | 1.1% |
| Age            |     |      |
| 18 to 24 years old | 248 | 11.4%|
| 25 to 34 years old | 365 | 16.8%|
| 35 to 44 years old | 654 | 30.0%|
| 45 to 54 years old | 303 | 13.9%|
| 55 to 64 years old | 247 | 11.3%|
| 65 or older    | 361 | 16.6%|
| Community      |     |      |
| Rural area     | 358 | 16.4%|
| Small city or town | 393 | 18.0%|
| Suburb near a large city | 662 | 30.4%|
| Large city     | 752 | 34.5%|
| Region         |     |      |
| South          | 826 | 37.9%|
| West           | 491 | 22.5%|
| Midwest        | 441 | 20.2%|
| Northeast      | 420 | 19.3%|

The category ‘prefer not to answer’ is not included in this table for gender, resulting in the % for those categories not adding up to 100. For the region variable, South: AL, AR, DC, FL, GA, KY, LA, MD, MS, NC, OK, PR, SC, TN, TX, VA, WV; Northeast: CT, DE, ME, MA, NH, NJ, NY, PA, RI, VT; Midwest: IL, IN, IA, KS, MI, MN, MO, NE, ND, OH, SD, WI; West: AK, AZ, CA, CO, HI, ID, MT, NV, NM, OR, UT, WA, WY. Consists of two combined samples collected from April 30-June 15, 2020 (n = 624) and August 7-26, 2020 (n = 1554).

Table 4
Paired sample t-tests for pre and during COVID-19 pandemic subjective well-being scores, nature-based activity scores, and outdoor activity scores among U.S. respondents (n = 2178).

| Variable                 | Pre COVID-19 | During COVID-19 | Paired t test |
|--------------------------|--------------|-----------------|---------------|
|                          | Mean          | SD              | Mean          | SD              | T   | p              |
| Subjective well-being    | 2.05          | 0.63            | 1.56          | 0.72            | 29.28 | <0.001         |
| Outdoor activities       | 1.19          | 0.63            | 0.77          | 0.63            | 29.99 | <0.001         |
| Nature-based activities  | 0.75          | 0.65            | 0.50          | 0.62            | 24.30 | <0.001         |

Response scale items for SWB included: At no time=0, Some of the time=1, Most of the time=2, All of the time=3. Response scale items for outdoor and nature activity groups included: Never=0, Every now and then=1, Often=2. All t-tests were significant after Holm-Bonferroni correction to family-wise error rates (Holm, 1979).

Fig. 1. Changes in outdoor activity participation rates (by type of outdoor recreation) before and during the COVID-19 pandemic for adults in the United States (n = 2178). Mean activity scores ranged from 0 (never participate) to 2 (often participate). Bars represent 95% confidence intervals.

3.4. Predicting Changes in SWB

We found support for H3, as those who engaged in more outdoor (B = 0.08, p < 0.05; Table 5) and nature-based (B = 0.20, p < 0.001; Table 5) activities prior to the pandemic experienced a smaller decrease in SWB. We also found support for H4, as those who continued to participate in outdoor activities (B = 0.25, p < 0.001; Table 5, Fig. 2a) and nature-based activities (B = 0.31, p < 0.001; Table 5, Fig. 2b) during the pandemic experienced a smaller decrease in SWB. Time period was also significantly related to change in SWB, indicating that those in the August sample experienced a more negative change in SWB than those who responded earlier in the June sample (B = -0.10, p < 0.01; Table 5). Our model was able to account for 35% of the variance in SWB (Adjusted R² = 0.354).

We found significant relationships between several demographic variables and changes in SWB and outdoor recreation. Females experienced a more negative change in SWB (B = -0.09, p < 0.01; Table 5) than males. Men reported 6% smaller declines in SWB than women, 8% smaller declines in nature based activities than women (t[2177] = -3.69, p < 0.001), and 2% smaller declines in outdoor activities (t[2177] = -2.19, p = 0.028; Table 6). Hispanic respondents reported more negative change in SWB than white respondents (B = -0.14, p < 0.001; Table 5). White respondents reported 11% smaller declines in SWB than Hispanics, 7% smaller declines in outdoor activities (F[4, 2173] = 3.11, p = 0.015) and 2% smaller declines in nature activities (F[4, 2173] = 2.82, p = 0.024, Table 6). When compared to the reference group of ‘aged 35 to 44 years old’, the age group ‘25 to 34 years old’ reported a more
negative change in SWB ($B = -0.09$, $p < 0.05$; Table 5). Finally, those who lived in a Midwestern state experienced a more negative change in SWB than those from the South ($B = -0.11$, $p < 0.01$; Table 5).

4. Discussion

Public health initiatives aimed at reducing the spread of COVID-19 may have unanticipated impacts on mental health. We found that adults’ SWB decreased throughout the pandemic, along with their participation in outdoor and nature activities. Those who engaged more in outdoor activities (playing sports outside, bicycling outside, going for walks or runs outside, swimming outside) and nature activities (wildlife viewing, camping, hiking, paddling, hunting, and fishing) prior to the pandemic, as well as those who continued to participate in outdoor and nature activities during the pandemic, experienced smaller declines in SWB. Self-reported declines in participation in outdoor recreation and nature-based recreation may be explained by several factors. First, those impacted by mental health challenges associated with COVID-19 simply may have lacked motivation to engage in outdoor recreation (Marashi et al., 2021). Another possible explanation is that several park amenities, such as basketball courts and outdoor sports fields were not open during much of the period for which we asked respondents to report their frequency of activity (Roth, 2020). Finally, the magnitude of outdoor transmission rates and the extent to which outdoor activities were safe was uncertain during the early phases of the pandemic (Freeman & Eykelbosch, 2020; Johnson et al., 2021), which may have kept many individuals indoors (Mateer et al., 2021).

Our findings build on mental health research by illustrating that baseline levels of engagement in outdoor and nature-based activities may render people more resilient to detrimental effects of natural disasters on well-being, and that this resilience is persistent over time. These findings align with the findings of Jackson et al. (2021), who found that prior participation in outdoor recreation activities, and continued participation in these activities during the COVID-19 pandemic, buffered adolescents against declines in SWB. More broadly, these findings suggest that outdoor and nature-based recreation...
Hispanic respondents than white respondents may reflect both cultural pandemic, and that these outcomes were associated with higher levels COVID-19 based on race and ethnicity (Gil et al., 2020; Helliwell et al., 2021). Furthermore, women may have also empathy among women relative to men (Guadagni et al., 2020). Feeling anxiety and insomnia when compared to men during the COVID-19 proactive policy can seek to identify those who are not engaging in long-term improvements in mental health. Similarly, Buchecker and Degenhardt (2015) found that outdoor recreation for those living in urban areas contributed to long-term improvements in both mental health and resilience to stress and adversity. Our finding that nature-based activities appeared to have a greater buffering effect against changes in SWB outdoor activities is consistent with prior research that finds nature-based recreation is more effective than general exercise for supporting well-being (Mitchell, 2015). This finding also supports the growing body of literature showing the beneficial effects of time in nature on mental health (Hartig et al., 2014, Bratman et al., 2015), revealing that these effects might be even more potent during a pandemic (Labib et al., 2022; Samuelsson et al., 2020).

Our findings also highlight the potential of continued engagement in outdoor and nature-based recreation during global crises to reduce impacts on SWB. Prior research found a positive relationship between time spent outdoors and psychological health for adults during the COVID-19 pandemic (Cindrich et al., 2021; Haider et al., 2021). Another study found those who spent more time outdoors were more psychologically resilient than others during the COVID-19 pandemic (Kilgore et al., 2020). Our study builds on these findings by identifying both the frequency and types of outdoor and nature-based activities that contributed to resilience in SWB during the pandemic. Interventions such as increased outdoor activities, social support, and exercise may be especially effective because they are (relative to fixed demographic attributes such as gender, age, and ethnicity) modifiable factors that contribute to resilience during crises (Kilgore et al., 2020). In essence, proactive policy can seek to identify those who are not engaging in outdoor activities at a high frequency and provide resources and access to do so as a means to buffer individuals against changes in well-being (Freeman & Eykelboom, 2020). Such an approach could help to combat expanding health inequities during the COVID-19 pandemic (Labib et al., 2021).

Weaker negative impacts on the SWB, and outdoor activities, of men relative to women may be explained by unequal impacts that women faced during the pandemic such as their increased burden to provide unpaid childcare (Power, 2020). Women were also exposed to unique health risks during the pandemic including a lack of access to reproductive healthcare, gender-based domestic violence, and psychological reactions to stress (Connor et al., 2020) – issues that are often magnified by structural inequities (Afifi, 2007). Internal factors may also contribute to these differences, as evidenced by one study that found women in Canada experienced higher levels of depression, trauma, anxiety and insomnia when compared to men during the COVID-19 pandemic, and that these outcomes were associated with higher levels of empathy among women relative to men (Guadagni et al., 2020). Females within U.S. universities similarly were at a higher risk for experiencing negative psychological impacts as a result of the COVID-19 pandemic (Browning et al., 2021). Furthermore, women may have also experienced greater impacts to their well-being because of a higher involvement than men within social networks that were disrupted by the COVID-19 pandemic (Eiberidge & Spantig, 2020).

Stronger negative impacts on the SWB, and outdoor activities, of Hispanic respondents than white respondents may reflect both cultural differences in the value of social relationships and differential impacts of COVID-19 based on race and ethnicity (Gil et al., 2020; Helliwell et al., 2021; The Economist, 2021). For example, the high value of social relationships in Hispanic cultures, linked to personalismo (developing close interpersonal relationships), familismo (commitment to family) (Harkness et al., 2020), and a tendency toward more cohesion within families compared to Whites (Knight, 1994) may have rendered Hispanics particularly vulnerable to changes in well-being during COVID-19 related to social distancing and isolation (Helliwell et al., 2021; The Economist, 2021). There is evidence for this trend on a global scale, as declines of happiness among more individualistic nations were smaller, or even non-existent, compared to Latin American nations during the COVID-19 pandemic (Helliwell et al., 2021). In the United States, disproportionate impacts may also be a result of Hispanics being particularly vulnerable to negative impacts of the pandemic including higher mortality rates, exposure to the virus, and associated illness (Fortuna et al., 2020; Hooper et al., 2020), limited access to healthcare, poor working conditions, and associated financial burdens (Gil et al., 2020). Disproportionate financial burdens may be explained by the fact that Hispanics, when compared to Whites, tend to have jobs that are not available to perform remotely (Buerbe & Bateman, 2020). Furthermore, Hispanics with non-citizens within their familial units also experienced disproportionate economic impacts during the COVID-19 pandemic (Gonzalez et al., 2020). Our finding that changes in SWB varied by region might be explained in part by regional differences in public health regulations during the study. For instance, differences in park use on a regional basis occurred during the COVID-19 pandemic due to inconsistency in the stringency of government policies related to safety measures (Geng et al., 2021; Slater et al., 2020). Weather conditions may have also played a role, assuming those within colder regions were less able to build psychological resilience through outdoor recreation prior to and during the COVID-19 pandemic due to weather. This notion is supported by a study that found a relationship between latitude and park visitation during COVID-19, likely driven by differences in weather conditions (Rice & Pan, 2020). This, in part, may explain why those in the Midwest experienced greater declines in SWB than those in warmer regions.

4.1. Limitations and Future Research

While the statistical generalizability of these findings are limited to adults within the United States, the trends align with findings regarding the importance of green space and outdoor recreation during COVID-19 for maintaining psychological health in other nations (see Javelle et al., 2021; Labib et al., 2022; Lesser & Nienhuis, 2020; Pouso et al., 2021), suggesting that outdoor recreation is important for building resilience to crises worldwide. However, cultural nuances may influence changes in SWB and changes in outdoor recreation. For example, in our study, we found Hispanic respondents experienced sharper declines in SWB than White respondents, which may be due to cultural factors (Helliwell et al., 2021; The Economist, 2021). Thus, future research should examine how cultural and other demographic differences influence the relationships between SWB and outdoor recreation during global crises. Another limitation is that our scale consisted of only four measures used to capture one element (SWB) of psychological health. More comprehensive measures of SWB that include additional items and more expansive response scales, as well as more objective measures of psychological and physical health outcomes, are needed in future research. Furthermore, more comprehensive measures of outdoor activities, including metrics that account for dosage such as intensity of participation (Shanahan et al, 2016), may provide additional detail that was not captured in the present study.

Although demographics for participants in this study reflected national demographics for age, region, gender, and ethnicity in the U.S., future research should attempt to measure and address potential biases in mental health status of participants from online survey panels given they may disproportionately engage individuals with mental health issues (Chauvenet et al., 2020). Another limitation of this study is that we relied on a retrospective pre-post methodology where respondents were asked to remember how they felt prior to the pandemic. In general,
individuals tend to exaggerate their previous positive affect as a means of supporting their own resilience (Colombo et al., 2020). Furthermore, those who are depressed tend to be less accurate in recall of their past activity levels and well-being. Future research should examine how intuitive policy responses for leveraging these findings affect activity participation and psychological health. For instance, the creation of built environments for a diverse group of potential users and the careful consideration of the location of parks have been recommended as long-term solutions to help address impacts of place-based interventions (e.g. park renovations) and future pandemics (Slater et al., 2020).

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5. Conclusions

This study highlights the potential to bolster resilience in times of crisis by effectivly communicating the importance of and providing opportunities for outdoor and nature-based recreation across diverse populations. Findings also suggest that proactive interventions to increase participation in outdoor recreation could help build resilience prior to global crises. Specifically, providing access to areas for safe recreation such as parks and other green spaces through infrastructure development and policy changes may be one crucial step to helping people cope with changes in psychological health during global disasters such as the COVID-19 pandemic (Labid et al., 2022; Slater et al., 2020; Samuelsson et al., 2020). As the likelihood of these events increases in the future (Myers & Patz, 2009), such interventions will become increasingly important for the promotion and preservation of psychological health and well-being.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research was funded by Grant No. G15AP00162 from the U.S. Geological Survey Southeast Climate Adaptation Science Center, which is managed by the USGS National Climate Adaptation Science Center.

Supplementary materials

Supplementary material associated with this article can be found in the online version, at doi:10.1016/j.wss.2022.100094.
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