## Mental wellbeing among higher education students in England during the pandemic: A longitudinal study of

1. **COVID-19 experiences, social connectedness and greenspace use**

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## Short title

1. Mental wellbeing of students in COVID-19

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## Data availability statement

1. Due to the sensitive nature of the information, risk for participant identification by subgroups and ethics
2. approval constraints, raw data cannot be shared.

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## Ethics statement

1. All aspects of the study were approved by the University of Oxford Central University Research Ethics
2. Committee (reference number: SSH\_OSGA\_C1\_21\_004). The authors confirm that all research meets BERA
3. ethical guidelines.

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1. The authors have no conflict of interest to disclose.

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## Mental wellbeing among higher education students in England during the pandemic: A longitudinal study of

1. **COVID-19 experiences, social connectedness and greenspace use**

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## Short title

1. Wellbeing of students during COVID-19

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## Abstract

1. The COVID-19 pandemic control measures substantially impacted the life of university students in the UK. While
2. multiple studies investigated early stages of the pandemic, focusing on risk factors for depression and anxiety,
3. fewer studies assessed later phases of the pandemic or examined positive protective factors for mental wellbeing.
4. Our longitudinal study investigated changes and associations between COVID-19 experiences, lifestyle behaviours,

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1. social connectedness and mental wellbeing in the second year of the pandemic. The validated Warwick-Edinburgh
2. Mental Wellbeing Scale (WEMWBS) was used to measure the primary outcome mental wellbeing. Self-reported
3. data from 161 university students (18-35-year-old) in England was obtained. Data collection took place across two
4. time points with contrasting COVID-19 epidemiological and countermeasure attributes. T1 occurred in the spring
5. of 2021, during the tail end of the third national lockdown when indoor household mixing was prohibited and
6. vaccination rates were low among the 18-35 years old. T2 took place six months later, in the fall of 2021, when
7. restrictions had ended and vaccination rates were high. Within-participant changes in students showed mental
8. wellbeing significantly improved over six months, suggesting positive adjustment. Fear of COVID-19 and

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1. engagement in COVID-19 protective behaviours significantly decreased as pandemic restrictions eased. Physical
2. activity levels were high and did not change over time, while greenspace visits significantly diminished. Social
3. support remained the same and group membership significantly increased over time. Hierarchal regressions
4. revealed social support was the most critical contributor to mental wellbeing. We discuss lessons for mental
5. wellbeing promotion strategies: encouraging use of greenspace as locations for distanced social interaction and
6. physical activity in times of lockdown constraints.

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## Keywords

1. Higher education, COVID-19; Mental Wellbeing; England

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## Key insights

1. **What is the main issue the paper addresses?**
2. Few studies focused on protective factors for mental wellbeing among university students during the COVID-19
3. pandemic in England. Using self-reported data from 161 students, this study longitudinally investigates changes
4. in and associations between COVID-19 experiences, lifestyle behaviours, social connectedness and mental
5. wellbeing in the second year of the pandemic.

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## What are the main insights the paper provides?

1. Findings revealed a significant increase in mental wellbeing over a six-month period from the spring to the fall of
2. 2021. Those with pre-existing mental health conditions reported lower mental wellbeing than their
3. counterparts, yet also experienced significant improvements over time. Social connectedness was a critical
4. contributor of mental wellbeing over time.

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# 3 Introduction

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1. Prior to the COVID-19 pandemic, concern for the mental health and wellbeing status of higher education
2. students was already on the rise in the UK (Hubble & Bolton, 2020). Evidence pointed to an increase in the
3. proportion (>30%) of students experiencing anxiety and depression (Auerbach et al., 2018; Insight Network,
4. 2020), and an increase in the number of students declaring a mental health concern upon entrance to university,
5. coupled with a high demand for mental health support (Williams et al., 2015). Understanding wellbeing
6. trajectories over time and identifying protective factors for wellbeing was determined to be of utmost

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13 importance (Thorley, 2017).

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1. The COVID-19 pandemic was challenging for university students, affecting all facets of their lives. Multiple
2. measures were put in place in the UK to limit the spread of COVID-19, including social distancing and masking
3. requirements, and the stringency level of these restrictions varied over time with case incidence, testing
4. capacities, vaccine roll-out, emerging variants, and social and economic pressures (Institute for Government,
5. 2021). Within higher education setting, in-person teaching moved online, campuses shut down and student
6. accommodations restricted socialization. While hospitalization and death were rare in young adults and COVID-
7. 19 symptoms were often mild, control measures were burdensome, causing important disruptions to studies,

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1. financial pressures, reductions in peer support networks, and recurrent isolation (Ihm et al., 2021). The impact
2. of these restrictions on the mental health and wellbeing of students is of concern (Burns et al., 2020),
3. particularly given the observed pre-pandemic ‘mental health crisis’ within UK universities (Hubble & Bolton,
4. 2020; Insight Network, 2020; Thorley, 2017). In fact, the early pandemic period is shown to have brought further
5. distress in these young adults (Evans et al., 2021; King et al., 2022; Savage et al., 2020, 2021; Zhu et al., 2021).
6. Considering the prolonged disruptions to university life, how students adapted over time and across constraints
7. remains to be thoroughly documented. Such knowledge would provide institutions with greater insights to guide
8. their approaches in future crises. This study longitudinally followed higher education students over six months

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32 during the second year of the pandemic, in the spring of 2021 and the fall of 2021.

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1. We begin by presenting key mental health concepts. We then introduce known protective factors for mental
2. health and mental wellbeing, summarize relevant findings from the UK pandemic literature and present the
3. current study.

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## Concepts and protective factors

1. To begin, we differentiate between concepts of mental health, mental illness, psychological distress and mental
2. wellbeing, and introduce the dual continuum model of mental health which underpins the present work. Most

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1. often, mental health is used as an umbrella or catch all term to describe the large spectrum of mental states,
2. such as experiences of mental illness/disorder, psychological distress and mental wellbeing. Mental illness
3. specifically refers to clinically diagnosable mental health conditions. There exist a wide range of mental illnesses,
4. which vary from severe and enduring, like bipolar disorder, to more common conditions like diagnosed general
5. anxiety disorder (GAD) and major depressive disorder (MAD). While not all those with a mental illness have a
6. medical diagnosis, those with mental illnesses experience symptoms which meet the severity threshold for
7. clinical criteria. Psychological distress, on the other hand, refers to a range of negative psychological states, such
8. as experiences of depressive mood or anxious states. While these experiences do not meet threshold levels for

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1. diagnosis of illness, they still represent mental suffering and ill-health. Although many individuals experience low
2. mood or unnecessary worry from time to time, prolonged and severe or disproportionate experiences of anxiety
3. or depression which interferes with daily functions, coupled with feelings of not having the inner capacity to
4. overcome these experiences, may constitute psychological distress (Barkham et al., 2019; Thorley, 2017).
5. Mental wellbeing is a complementary notion that emerged from strength-based and salutogenic approaches.
6. Focus is placed on an individual’s personal strength, agency and social networks, instead of their deficits. Mental
7. wellbeing encompasses hedonic and eudaimonic philosophies, constituting high levels of positive affect, low
8. levels of negative affect, and satisfaction of life, with self-realization (Ryan & Deci, 2001; Ryff & Singer, 2008). In

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1. short, mental wellbeing refers to aspects of feeling good and functioning well and sits on a continuum running
2. from low to high. By focusing on positive experiences, wellbeing lends itself well to health promotion strategies.
3. The dual continuum model poses mental wellbeing and mental illness as distinct but related notions that
4. uniquely contribute to overall mental health. The model is illustrated as two continuums, perpendicularly
5. superimposed (Keyes, 2017; Thorley, 2017). On the x axis is one continuum, where mental illness sits on one
6. end, representing the presence of clinically diagnosable mental health conditions, and on the other end a person
7. is characterized as free from mental illness. In the middle exists a spectrum of psychological distress. On the y
8. axis lies the continuum of wellbeing from high to low. Individuals can find themselves in all quadrants of the

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1. model, experiencing high or low wellbeing, with or without a diagnosed mental health condition. In line with
2. this, in our work, we measure mental wellbeing while accounting for prior mental health history of clinical
3. diagnosis.

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1. As evidenced in systematic reviews, numerous factors contribute to individuals’ mental health and wellbeing,
2. spanning multiple levels of influence, from individual characteristics and lifestyle factors, to interpersonal and
3. community networks, and physical and social environments (Bronfenbrenner, 1977). While such factors of
4. influence vary by population subgroup and geographical context, we summarize known factors at varying levels

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1. of influence, particularly among the university student population. Documented in a wide range of self-reported
2. surveys, female students are at greater risk of reporting psychological distress and lower mental wellbeing.
3. Similarly, those who identify as non-heterosexual, of an ethnic minority, and those with a history of childhood
4. trauma or a history of prior mental health condition also report poorer mental health and lower wellbeing
5. outcomes than their counterparts (Campbell et al., 2022a; Neves & Hillman, 2019). Certain psychological factors
6. are found to have positive protective effects. Optimism, self-efficacy, resilience, grit, and use of positive
7. reappraisal are all associated with greater wellbeing (Campbell et al., 2022b). As for modifiable behaviours,
8. evidence presented in systematic reviews demonstrate a strong link between greater physical activity and
9. wellbeing. Indeed, across all ages regular physical activity is shown to significantly improve mental health by

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1. reducing symptoms of depression, anxiety and stress, and plays a role in the promotion of mental wellbeing,
2. even at low doses (Mikkelsen et al., 2017; Teychenne et al., 2020). Sleep quality, healthy diets and a reduction in
3. alcohol consumption are also demonstrated to have significant positive impacts on a number of mental health
4. and wellbeing outcomes (Heinsch et al., 2022). Moreover, there is a growing body of literature on the positive
5. role of social connectedness for mental wellbeing. Key elements of connectedness among the general and
6. student population include socialising and social support (Adams et al., 2021; Campbell et al., 2022a; Duffy et al.,
7. 2020; Gariépy et al., 2016; Heinsch et al., 2022). While considerable variation exists in the manner in which
8. these concepts are measured, findings overwhelmingly converge towards their positive impact on wellbeing.

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1. Certain environmental attributes are also found to have positive contributions towards wellbeing (van den Berg
2. et al., 2015). It is demonstrated, for instance, that greenspaces provide low cost andattractive environments for
3. people to engage in physical activity and social interactions, and that the participation in these activities can, in
4. turn, lead to greater psychological outcomes (Markevych et al., 2017). All these factors and levels of influences
5. interact together and are useful in the development of wellbeing promoting strategies; as found in integrated
6. ‘whole university approaches’ which aim to foster and promote wellbeing in students (Universities UK, 2018,
7. 2020). With the role of these factors during the pandemic initially unknown or undocumented, multiple studies
8. investigated their influence on mental health and wellbeing, including among university students. There is still a
9. need to see how such university initiatives should be applied in the context of a global crisis such as the

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54 pandemic.

## UK studies among university students during the pandemic

1. While the pandemic was global, its epidemiology differed by country, population and public health counter
2. measures; hence, there is relevance to focus on a specific country, age group and context to better assess

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1. psychological adjustment trajectories. In the UK, a substantially greater number of studies investigated
2. psychological distress (such as depressive mood and anxiety) over wellbeing among university students (Lemyre
3. et al., 2023; Zhu et al., 2021). Such studies looked at numerous variables, including academic outcomes (Appleby
4. et al., 2022; Gadi et al., 2022), physical activity (Savage et al., 2020, 2021), sleep (Evans et al., 2021; Owens et al.,
5. 2022), alcohol use (Carr et al., 2021; Evans et al., 2021), loneliness (Evans et al., 2021), social connectedness
6. (Chen & Lucock, 2022), mobile phone use (Catling et al., 2022), and trust in government (Defeyter et al., 2021).
7. Generally, studies did not explicitly investigate use of the outdoor environment and few explicitly recorded
8. COVID-19-related experiences and stressors such as fear of infection (Appleby et al., 2022; Chen & Lucock, 2022;

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1. Evans et al., 2021). Few studies accounted for the prior mental health history of students (Bennett et al., 2022;
2. Carr et al., 2021; Chen & Lucock, 2022). Lastly, most methodologies were cross-sectional, and while some
3. successfully leveraged prior work to permit pre- and during-COVID-19 comparison (Evans et al., 2021; Savage et
4. al., 2020), few had longitudinal data stretching beyond the early stages of the pandemic (> 6 months) (Bennett
5. et al., 2022; Owens et al., 2022; Savage et al., 2021). More longitudinal designs are required. Longitudinal
6. trajectories of psychological distress and wellbeing differed over time in students during the pandemic. Nearly
7. all studies investigating the early-stages of the pandemic in students found high levels of anxiety, depression,
8. and perceived stress (Carr et al., 2021; Chen & Lucock, 2022; Evans et al., 2021; Owens et al., 2022; Savage et al.,

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1. 2020, 2021), and low levels of mental wellbeing (Donald & Jackson, 2022; Evans et al., 2021; Savage et al., 2020,
2. 2021). Where assessed, psychological distress and mental wellbeing was usually worse among females than
3. males (Carr et al., 2021; Chen & Lucock, 2022; Owens et al., 2022). When considered, those with a prior history
4. of mental health difficulties tended to score higher on depression and anxiety scales during the pandemic
5. (Bennett et al., 2022; Chen & Lucock, 2022). In terms of COVID-19 experiences, worry about family members
6. and friends developing COVID-19 was greater than concern for one self (Appleby et al., 2022; Evans et al., 2021).
7. Aside from asking if students followed COVID-19 government guidelines, studies in the UK have not taken an in-
8. depth look at engagement in protective behaviours. In terms of lifestyle behaviours, studies reported a
9. reduction of physical activity at the onset of the pandemic (Savage et al., 2020) and in later stages (Savage et al.,

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1. 2021). One study by Chen & Lucock (2022) found communication with friends and family to be the biggest
2. predictor of lower depression levels, after physical activity. Two focus-group studies in Jan 2021 also found
3. social support to be a recurrent theme of importance (Al-Oraibi et al., 2022; Knight et al., 2021). A systematic
4. review of wellbeing studies conducted among university students found that in the early pandemic phase, when
5. restrictions were high and included lockdowns with stay-at-home orders, most studies reported significant
6. reductions in student wellbeing in comparison to before the pandemic. In later stages, however, studies did not
7. demonstrate consistent worsening of wellbeing, with mixed results observed (i.e., improvements, no changes,
8. and impairments) across late 2020 and 2021 (Lemyre et al., 2023). Lemyre et al., (2023) also noted that no

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1. longitudinal study on wellbeing concomitantly investigated the role of environmental correlates in support of
2. student wellbeing. This present study will add to the body of evidence by documenting mental wellbeing
3. trajectories later in the pandemic across 2021. It will substantiate the current evidence on contributing factors
4. for wellbeing, such as physical activity and social connectedness, as well as provide novel findings on the role of
5. greenspace in support of wellbeing during the pandemic. These lifestyle and behaviour variables were
6. investigated as they would have been substantially impacted by the socialization and mobility restrictions of the
7. pandemic and will help elucidate the role of the restrictions on the student experiences across the different
8. stages of the pandemic constraints.

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## Present study

1. Since the epidemiological and social distancing policy profile of countries differed considerably throughout the
2. pandemic, it is sensible to undertake country-specific research to map countermeasures with outcome

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1. measures. In the UK, multiple studies investigated the early stages of the pandemic, focusing on risk factors for
2. depression and anxiety with fewer studies looking at later phases of the pandemic while investigating positive
3. protective factors for mental wellbeing (Lemyre et al., 2023). Our study endeavoured to longitudinally examine,
4. in the second year of the pandemic, changes in behaviours and mental wellbeing of university students. Our
5. research objectives aimed at these three questions:
6. (1) What are the changes in COVID-19 experiences, lifestyle behaviours, social connectedness and mental
7. wellbeing of university students over time one year into the pandemic?
8. (2) What are some of the factors associated to mental wellbeing at each time point?

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16 (3) What are the predictors of changes in mental wellbeing as the pandemic evolved?

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1. We hypothesized (H1) that as the pandemic progressed and the UK imposed fewer socialization restrictions we
2. would see adaptation to context, with less fear, worry and COVID-19 protective behaviours, more physical
3. activity and greenspace use, more group membership and social support, and greater mental wellbeing. We
4. expected (H2) that the association between behaviours and mental wellbeing would differ at T1 and T2 given
5. students would adapt to the pandemic context, with COVID-19 experiences and lifestyle behaviours being more
6. important at T1. We hypothesized (H3) predictors of change in mental wellbeing would include physical activity,

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25 greenspace use and social connectedness.

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# Methods

## Study design and participants

1. We designed a longitudinal observational study investigating young adult university students in England in the
2. second year of the COVID-19 pandemic using a convenience sample. Data collection took place in April-May

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1. 2021 (T1) and six months later, in Nov-Dec 2021 (T2), for those who agreed to be contacted again. Students
2. from four universities in England (Oxford Brookes University, University of Oxford, University of Southampton
3. and Solent University) were invited to participate by their departments and college administrators via email. The
4. Qualtrics survey link was also shared on student WhatsApp groups, Facebook pages and Twitter. Three email
5. reminders were sent out and participants could win a £10-£50 Amazon vouchers at each wave. Students
6. provided informed consent and ethics approval was granted by the University of Oxford Central University
7. Research Ethics Committee (SSH\_OSGA\_C1\_21\_004). In planning our study, we conducted *a priori* power
8. calculations to determine our target sample size for longitudinal analyses. Based on T1 responses, we also
9. carried out power calculation before launching T2 to determine our target response rate. For two-tailed tests,

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1. with an alpha of .05, power of .80, and a medium effect size detected, the following sample sizes were needed,
2. assuming a female to male ratio of 2, as observed in T1: paired t-test (n = 34) and multiple regression with at
3. most 12 predictors (n = 127). From 424 participants at T1, we aimed for a minimum response rate of 40% at T2.
4. We obtained 52%, with 183 respondents. Of these, 22 were removed for no longer being students. This study
5. presents longitudinal results of these 161 participants (Appendix **Figure A.1**).

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## COVID-19 situation in England at time of study

1. The epidemiology and the countermeasure policy profile of the COVID-19 pandemic varied importantly through

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1. time. At T1, in April-May 2021, there were approximately 2,500 cases per day in England. Vaccination had just
2. begun for the 18-29 and 30-39-year-old, the last two priority groups. Between 13%-25% of those aged 18-24, 25-
3. 29, and 30-34 had received one dose of a COVID-19 vaccine (UK Government, 2022). Emphasis was still placed
4. on non-pharmaceutical interventions to limit the spread of disease, such as hand washing, mask wearing, and
5. reduction of social contacts. England was in the tail end of the third national ‘lockdown’. Retail venues were
6. open for visitation. Indoor household mixing was prohibited but outdoor gatherings of up to six individuals were
7. allowed (Institute for Government, 2021). Within university settings, multiple strategies were in place to
8. mitigate infection risks. For instance, masking and social distancing requirements were enforced, hand sanitizing

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1. stations were widely available, new cleaning protocols were implemented, ventilation was recommended, limits
2. to room occupancy were in place and foot traffic was redirected to one-way systems. The concept of
3. ‘household’ was introduced within accommodations to designate groups of students living in the same vicinity
4. and sharing a kitchen or bathrooms. Students were encouraged to limit contact with those outside their
5. households. Furthermore, most courses continued to be held online (Hubble & Bolton, 2021). Referring to the
6. often cited COVID-19 Government Response Tracker Stringency Index (Hale et al., 2021), a composite measure
7. of nine metrics recording the strictness level of ‘lockdown’ measures (e.g., restrictions on gathering size and
8. stay-at-home requirements), the stringency index score was at around 60 over 100 during this period. By

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1. comparison, in April 2020, at the start of the pandemic, the index was at 80 over 100 (Hale et al., 2021). Six
2. months onwards, at T2, in Nov-Dec 2021, there was a 14-fold increase in cases, with about 35,000 cases per day.
3. Approximately 65% of those aged 18-34 had received at least one dose of a vaccine – all were eligible to get
4. vaccinated (UK Government, 2022). England was substantially more ‘open’. Most limits on social contacts were
5. removed and venues were open. The stringency index was 45 over 100 (Hale et al., 2021). Within university
6. settings, face-to-face teaching had resumed. Students were encouraged to continue wearing masks in
7. classrooms and social settings. Rapid testing was free, easily accessible and encouraged, and many universities
8. had on campus PCR testing centres. Importantly, our data was collected before the wide spread of the Omicron

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1. variant.

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## Measures

1. **Sociodemographic.** Age, sex, gender, ethnicity and sexual orientation was collected using the England 2021
2. Census questions. Other questions included study level, student status, accommodation type, and living
3. arrangement.

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1. **COVID-19 related experiences.** Based on the Student COVID-19 Insights Survey (SCIS) in England, participants
2. indicated if they had ever taken a COVID-19 test, ever tested positive, knew someone personally who had

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1. contracted COVID-19, knew someone personally who had gotten very sick or died of COVID-19 and if they were
2. vaccinated.

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1. The frequently cited 7-item Fear of COVID-19 scale was used (Ahorsu et al., 2020). Items were rated on a 5-point
2. scale (“Strongly disagree” to “Strongly agree”). An overall score was calculated by totalling each item. T1 and T2
3. Cronbach’s α were 0.85 and 0.84, respectively.

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42 Similar to other studies (Evans et al., 2021), we also included a scale to assess worry of COVID-19 infection.

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1. Participants rated worry levels on a 5-point Likert scale (“Not at all” to “Extremely”) for: i) Contracting COVID-19;
2. ii) Transmitting COVID-19; iii) Needing hospitalization due to a COVID-19 infection; iv) Having to self-isolate due
3. to a positive COVID-19 test; and v) Having to self-isolate as a result of being a close contact. An overall score was
4. calculated by totalling each item. T1 and T2 Cronbach’s α were 0.74 and 0.71, respectively.

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1. Based on published studies (Chen & Lucock, 2022; Elmer et al., 2020), we measured engagement levels in
2. protective non-pharmaceutical intervention (NPI) behaviours. Participants rated on a 5-point Likert scale (“Very
3. rarely” to “Very often”), how frequently they took part in behaviours: i) Wearing a face mask where required; ii)
4. Wearing a face mask where not required; iii) Hand washing; iv) Avoiding contact with high-risk individuals; v)

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1. Avoiding public places; vi) Avoiding public transit; vii) Avoiding crowded places; viii) Keeping a distance from
2. those not in household or support bubble; and ix) Following government COVID-19 guidance. An overall score
3. was calculated by totalling each item. T1 and T2 Cronbach’s α were 0.80 and 0.84, respectively.

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1. **Lifestyle behaviours.** First, for comparison with the literature (Carr et al., 2021; Gadi et al., 2022; Gestsdottir et
2. al., 2021; Owens et al., 2022), recall questions on perception of changes in behaviours between current (T1) and

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1. pre-pandemic times were asked. Participants answered the question “*Rate how much your behaviours compare*
2. *to before the COVID-19 pandemic*” on a 5-point Likert scale (“A lot less” to “A lot more”), with “I don’t know”
3. and “I do not do this” options for: i) Physical activity; ii) Sleep; iii) Healthy eating; iv) Alcohol consumption; v) Use
4. of social media; and vi) Greenspace visits.

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1. Second, we used an indicator to assess frequency of physical activity, as done in other well established student
2. surveys (Duffy et al., 2020; Goodday et al., 2019). Physical activity was defined as a minimum of 20 continuous
3. minutes of any form of exercise. Selecting from five options (“Never” to “Daily”), participants reported weekly

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1. levels of physical activity. Responses were treated as Likert scale on a continuum from 0 to 4, where 0
2. corresponds to no exercise and 4 to daily exercise.

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1. Lastly, similar to the one in the People and Nature survey for England (Natural England, 2020), we included an
2. indicator to measure greenspace use. Greenspace was defined as any area of vegetated land, including public
3. and private spaces such as parks and gardens. Selecting from six options (“Never” to “Daily”), participants
4. reported monthly frequency of visits to greenspaces. Responses were treated as a Likert scale on a continuum
5. from 0 to 5, where 0 corresponds to never and 5 to daily visits.

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1. **Social connectedness.** Questions were adapted from the New Zealand General Social Survey (Frieling et al.,
2. 2018). Socialization and social participation was operationalized as participation in groups, clubs or
3. organizations. Social support was assessed by asking participants if they had a friend, family members or a
4. partner they could rely on if they had serious problems.

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1. **Mental wellbeing and prior mental health.** The well-known and validated 14-item Warwick-Edinburgh Mental
2. Wellbeing Scale (WEMWBS) was used to measure mental wellbeing. It captures notions of positive mental
3. wellbeing and covers both hedonic and eudaimonic perspectives (Tennant et al., 2007). Participants rated

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1. statements on a 5-point Likert scale (“None of the time” to “All of the time”). An overall score was calculated by
2. totalling each item. Cronbach’s α on the total score were 0.91 and 0.92, respectively at T1 and T2. Lastly, to
3. assess previous mental health difficulties, participants were asked if they had ever been told by a health care
4. professional they had a mental health condition.

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## Statistical analyses

1. Means, standard deviations and ranges were calculated for continuous variables, while frequencies and
2. percentages were calculated for categorical variables. Baseline characteristics of dropouts were assessed against

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1. those who completed follow up. For research question 1 regarding changes over time, paired t-tests and
2. McNemar tests were conducted. Normality assumptions were statistically verified with the Shapiro-Wilk test.
3. Two-way repeated measures mixed ANOVA were conducted to account for within (i.e., time) and between
4. subject factors (i.e., gender or pre-existing mental health condition), testing for main and interaction effects.
5. Assumptions were tested using Levene’s test, Mauchly’s test and Box’s M test. If assumptions were violated, the
6. robust version of the mixed ANOVA was run. For research question 2 on factors of mental wellbeing at each
7. time point, Pearson correlations were examined, followed by hierarchical linear regressions. Unstandardized and
8. standardized betas (β) were calculated and model goodness of fit was assessed using adjusted R2. For research
9. question 3, on predictors of changes in mental wellbeing, we performed multiple linear regression analysis on

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1. the T2 WEMWBS scores while adjusting for scores at T1. Assumptions for linearity, normality, and
2. homoscedasticity were checked. Tests were run with two-sided probability and an alpha of 0.05. Gender was
3. dichotomous, with women and gender diverse individuals grouped (i.e., non-binary, transgender, agender,
4. gender fluid), as done in other studies (Bennett et al., 2022; Defeyter et al., 2021). Power calculations were done
5. using the G\*Power program (version 3.1.9.7) (Faul et al., 2007). The Strengthening the Reporting of
6. Observational Studies in Epidemiology (STROBE) guidelines were used in the presentation of results (STROBE,

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7 2022). All analyses were conducted in R (version 4.0.3) (RStudio Team, 2022).

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# Results

## Sociodemographic characteristics

1. **Table 1** presents baseline characteristics of the longitudinal sample (*N* = 161). Briefly, mean age was 22.6 (*SD* =

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1. 3.88). Most participants were women (67.1%), white (76.8), heterosexual (71.8%), undergraduate (60.4%) and
2. full time students (98.8%). About half lived in university accommodation (41.6%) and half in private (58.4%),
3. almost all under shared arrangement (91.3%). More than a quarter (29.5%) had been told by a health care
4. professional they had a mental health condition.

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1. Those who did not complete follow-up at T2 were more likely at T1 to be younger, man and undergraduate, but
2. did not differ in terms of mental wellbeing, t(353) = 1.57, *p* = .12. With the exception of a slightly greater
3. proportion of females, our sample was similar on age and ethnicity to the 2020/2021 Higher Education Student
4. Statistics for England (Higher Education Statistics Agency, 2022). We found similar proportion reporting a mental

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23 health condition in the University Student Mental Health Survey (26.6%) (Insight Network, 2020).

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1. [Insert Table 1]

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## Comparisons with retrospective pre-pandemic data

1. As a preliminary step for comparison purposes with the published literature, we collected self-reported
2. retrospective pre-pandemic lifestyle behaviour data, allowing for a greater understanding of trends over time.
3. We asked participants to recall their pre-pandemic levels of engagement in lifestyle behaviours and compare it

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1. with their current level of engagement (T1) (Appendix **Figure A.2**). High proportions reported doing less physical
2. activity and having less sufficient sleep than before the pandemic (44% and 37%, respectively). Half observed no
3. change in their healthy-eating habits. Similar proportions reported a decrease in alcohol consumption versus an
4. increase (37% and 38%, respectively). And lastly, the majority reported using social media and visiting
5. greenspaces more frequently compared to before the pandemic (70% and 62%, respectively).

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## Changes within the pandemic

1. **COVID-19 experiences.** COVID-19 testing, cases and vaccination were assessed. Responses revealed that at T1,
2. 88.2% had ever taken a COVID-19 test and 7.5% had ever tested positive. By T2, nearly all had ever taken a test

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1. (94.7%) and the ever positive rate stood at 16.7%. At both time points, most knew someone personally who had
2. contracted COVID-19 (T1: 85.7%; T2: 92.6%), and about a third knew someone who had gotten very sick or died
3. from COVID-19 (T1: 32.0%; T2: 33.8%). By T2, 98.7% said they were partially or fully vaccinated.

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1. Results from paired t-tests revealed a significant decrease in COVID-19 fear between T1 and T2, t(152) = -3.95, *p*
2. <.001 and a significant reduction in COVID-19 NPI protective behaviour engagement between T1 and T2, t(151) =
3. -13.84, *p* < .001 (**Table 2**). We investigated differences in COVID-19 fear and NPI protective behaviour
4. engagement by gender. Repeated measures mixed ANOVA with time as a within-subject factor and gender as a

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1. between-subject factor were conducted. For COVID-19 fear scores, there was a significant main effect for time
2. (F(1, 111) = 9.33, *p* = .003), confirming results from paired t-tests, as well as a significant main effect for gender
3. (F(1, 117) = 20.15, *p* < .001), with lower scores for men. There were no significant two-way interactions,
4. indicating that the impact of time on fear of COVID-19 did not vary according to gender (*p* = .52). Similarly, for
5. NPI protective behaviour engagement, there was a significant main effect for time (F(1, 108) = 109.42, *p* < .001)
6. and gender (F(1, 92) = 7.03, *p* = .009), with decreasing scores over time and lower sores for men; but no
7. interaction (*p* = .86).

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1. **Lifestyle behaviours.** Physical activity levels were overall high, with half reporting exercise at least four times a
2. week (T1: 54.0%; T2: 50.7%). Within-subject comparisons of frequency of weekly physical activity scores showed
3. no significant differences in time (**Table 2**). A mixed ANOVA confirmed no change in time (*p* = .31), with a gender
4. effect F(1, 129) = 3.97, *p* = .04, whereby men scored lower, but no interactions (*p* = .60). For greenspace use,
5. 37.9% reported visits at least four times a week at T1, and 19.2% at T2. A significant decrease in frequency of the
6. greenspace use score was seen between T1 and T2, t(155) = -4.28, *p* <.001 (**Table 2**). A mixed ANOVA confirmed
7. the time effect F(1, 108) = 10.90, *p* = .001, with no gender effect F(1, 113) = 1.02, *p* = .31; nor interaction (*p* =
8. .21).

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1. **Social connectedness.** We observed a significant increase in group membership from T1 (75.2%) to T2 (83.0%)
2. based on McNemar repeated-measure Chi-square test (*X*2 (1, *N* = 153) = 4.80, *p* = .03). Overall, levels of social
3. support remained high and no change were found from T1 (89.0%) to T2 (87.7%) (*X*2 (1, *N* = 154) = 0.22, *p* = .64).

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1. **Mental wellbeing.** Results from paired t-tests revealed a significant overall improvement in mean mental
2. wellbeing over time during the pandemic between T1 and T2, t(153) = 2.59, *p* = .01 (**Table 2**).. Repeated
3. measures mixed ANOVA showed a significant main effect for time (F(1, 152) = 7.97, *p* = .005) but not for gender

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25 (F(1, 152) = 0.28, *p* = .60), with no interacting effect, indicating the impact of time on the outcome did not

26 depend on gender (*p* = .25). A significant main effect was detected for pre-existing mental health condition (F(1,

27 147) = 32.09, *p* < .001) with those having received a prior medical diagnosis reporting significantly less wellbeing

28 at both time points. There was also a time effect (F(1, 147) = 9.47, *p* < .001) with all showing improvements in

29 mental wellbeing. There were no interaction effects (*p* = .59).

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31 [Insert Table 2]

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## 33 Positive factors for mental wellbeing at each time point

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1. Our second study objective was to identify protective factors associated with greater mental wellbeing at both
2. time points, separately. We expected different contributors would come to the foreground in regression
3. analyses, underscoring the role of the pandemic context and therefore the need to tailor mitigation strategies to
4. lessen the unintended consequences of the restrictions, with T1 (spring 2021) being under more stringent
5. national restrictions than T2 (fall 2021).

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1. First, correlations were examined between mental wellbeing and all variables to understand bivariate
2. relationships. At T1, when England was in the tail end of the third lockdown, greater mental wellbeing was

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1. associated with lower fear of COVID-19, more physical activity, more greenspace use, reporting group
2. membership, having social support and having no prior mental health diagnosis. At T2, when restrictions were
3. lifted, group membership, social support, and no prior mental health history remained related to mental
4. wellbeing, with the addition of engaging in COVID-19 NPI protective behaviour (Appendix **Table A.1**). Two
5. hierarchical linear regression models on complete cases were conducted, one at T1 and one at T2, to enable the
6. comparison of the pandemic context onto the outcome. In hierarchical regressions, predictors are added by
7. block, such that each subsequent model is bigger than the previous one. This method is used to demonstrate
8. whether newly added blocks of variables explain the outcome above and beyond prior smaller models. **Table 3**
9. presents the model at T1 in the spring 2021. Age, gender and sexual orientation were entered in step 1 as

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1. controls. COVID-19 experiences were added in step 2, with no significant contribution to the model, meaning
2. these variables did not explain mental wellbeing. Physical activity and greenspace use significantly improved the
3. model in step 3. Here, the unique contribution of greenspace use was highlighted as significant for mental
4. wellbeing. In step 4, group membership and social support were added and showcased the shared variance
5. between the lifestyle behaviours. Eighteen percent of the variance in wellbeing was explained. Finally, prior
6. mental health history was included to demonstrate how the model held true also for people with prior

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1. conditions. It explained a further 12% of variance above and beyond all prior variables, for a total R2 of 0.30. To
2. demonstrate the role of the pandemic context six months later in the fall of 2021, model building at T2 was
3. done in the same manner among the same individuals (**Table 4**). At T2, in step 1, sociodemographic variables
4. were entered as controls, with sexual orientation being significant. In step 2, engaging in COVID-19 NPI
5. protective behaviours was significant, as was sexual orientation. Physical activity and greenspace use did not
6. improve the model. However, social connectedness in step 4 added a unique significant contribution for group
7. membership and social support, with an additional 17% of the variance in mental wellbeing and replacing the
8. role of sexual orientation and NPI protective behaviours. Finally, prior mental health history in step 5 added 9%

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16 of explained variance, maintaining the contribution of social connectedness.

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1. [Insert Table 3]
2. [Insert Table 4]

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## Predictors of longitudinal *change* in mental wellbeing across the pandemic

1. To study *change* in our observational non-experimental setting we built a longitudinal model with T2 WEMWBS
2. scores as the outcome, firstly regressing on T1 WEMWBS scores, then adding T2 COVID-19 experiences, lifestyle

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1. behaviours and social connectedness. The estimated coefficients indicate the increase in the outcome WEMWBS
2. in the fall 2021 (T2) at the within-subject level, relative to scores in the spring 2021. Individual level variables
3. which do not change over the study period, such as age, gender, and pre-existing mental health condition were
4. not included as the analysis looks at within-subject changes. Results demonstrate the importance of social
5. connectedness, with both social support and group membership as significant contributors to increased mental
6. wellbeing at T2, relative to T1 (**Table 5**).

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32 [Insert Table 5]

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# Discussion

1. Our study explored changes in, and associations between, behaviours and mental wellbeing in higher education
2. students across time during the second year of the pandemic, and aimed to identify enablers of adaptation.
3. Since students are identified as at-risk for poor wellbeing (Hubble & Bolton, 2020), documenting how they fared
4. and adapted during the pandemic is of critical importance (Burns et al., 2020).

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## Main findings

1. **Comparisons with pre-pandemic.** To establish a preliminary comparison with the published literature, we asked
2. participants to retrospectively report changes in behaviours with pre-pandemic times. Students mentioned a
3. decrease in physical activity and insufficient sleep, with as many describing a decrease in alcohol consumption
4. versus an increase. They reported an important uptake in social media use and greenspace visits. Studies doing
5. comparable assessments reported similar tendencies (Carr et al., 2021; Gadi et al., 2022; Owens et al., 2022),
6. further validating our self-report questionnaire. Of course, we caution these results with recall bias risk. Still,
7. other longitudinal studies with pre- and during-Covid data have confirmed a decrease in physical activity (Savage

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1. et al., 2020, 2021) and a decrease in alcohol consumption (Evans et al., 2021; King et al., 2022). The pandemic
2. countermeasures did bring report of change in behaviours.

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1. **Longitudinal *changes* within the pandemic: COVID-19 experiences.** We hypothesized that as the pandemic
2. progressed and the UK imposed fewer restrictions we would see adaptation to context. Indeed, while we
3. observed substantial fear of COVID-19 in students at T1, there was a significant decrease during the pandemic.
4. This paralleled the epidemiological and restriction context of the country, given the increased vaccination rates
5. and the lowering of the restriction stringency index, reflecting proper adjustment. Meta-analyses of studies

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1. using the same fear scale (FCV-19S) suggests our observed mean levels were generally lower than those
2. observed internationally among university students and the general population earlier in the pandemic. We
3. suspect this reflects differences in COVID-19 severity over time as we collected data in the second year of the
4. pandemic when there was less uncertainty surrounding the disease, restrictions were beginning to ease,
5. vaccination had begun and people were likely used to being on the receiving end of constant COVID-19
6. information. Gender differences were similar, with men reporting less fear (Luo et al., 2021; Wang et al., 2022).
7. We also saw a decrease in scores on our COVID-19 NPI protective behaviour engagement scale over time. Of
8. significance, we found that students reported less fear of COVID-19 over time and were more worried about

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1. transmitting the infection to others (T1: 39.1%; T2: 30.5%) compared to contracting it themselves (T1: 18.0%; T2:
2. 14.9%). Appleby et al. (2022) reported a similar trend in their cross-sectional Canada-UK student sample in May
3. 2020, as did Evans et al. (2021) in their pre- and during-Covid (May 2020) UK student sample. Such findings may
4. be used in a sensible way to help frame messaging to encourage adherence to behavioural advice, with caution
5. to not incite fear and worry beyond the true risk of disease.

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1. **Longitudinal *changes* within the pandemic: lifestyle behaviours.** In our study, high levels of physical activity
2. were sustained across both time points in 2021. Earlier UK studies with recall or pre- and early-Covid design

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1. reported a decrease in physical activity among students (Savage et al., 2020, 2021). Previous decline may reflect
2. the abrupt onset of stay-at-home orders prompting drastic changes in habits. At later times, in the second year
3. of the pandemic, high levels of activity were observed and suggest students had settled into their ‘*new normal*’.

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1. Our study is unique in having assessed use of greenspaces. We observed a significant reduction in frequency of
2. greenspaces visits over time as restrictions eased up, contrary to what we expected. We suspect levels were
3. greater in the spring of 2021 as indoor household mixing was prohibited but outdoor gatherings of up to 6 were
4. allowed. The decrease may also be related to seasonality from spring to fall. While no other UK wellbeing studies
5. investigated use of outdoor natural spaces among university students (Lemyre et al., 2023), some studies among

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1. the general population did, finding an uptake in visits to greenspace in the early (Geng et al., 2021; Natural England
2. & Kantar Public, 2021) and late stages of the pandemic (Burnett et al., 2022). While direct comparisons are not
3. possible due to differing timeline, the contrasting trajectory between our sample and the general population may
4. reflect age differences, with older adults generally reporting more interest in parks and natural environments
5. (Boyd et al., 2018; Burnett et al., 2022; Natural England & Kantar Public, 2021). Our analyses suggest greenspace
6. use was not linked to COVID-19 fear as they were not correlated. Instead, greenspace use was related to physical
7. activity, as well as to group membership and social support at T1, suggesting greenspace provided a vector for
8. social connectedness under restriction times.

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1. **Longitudinal *changes* within the pandemic: social connectedness.** In line with our hypothesis on adaptation to
2. COVID-19 context, group membership increased between T1 and T2, once national restrictions allowed for
3. greater social participation in groups, clubs and organizations. Throughout our study, students reported
4. moderately high levels of social support over the six-month period. Consistent with our results, international
5. longitudinal studies observed no changes in perceived social support among university students (Elmer et al.,
6. 2020; Hamza et al., 2021). In a similar manner, in the general UK population, despite fears of a loneliness
7. epidemic as a result of the pandemic, little evidence was found for increased reports of loneliness compared to
8. before beyond the first few months of the pandemic (Foa et al., 2020). The 2021 World Happiness Report

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1. compiled findings from studies across countries during the pandemic, including the UK, also noted the positive
2. role of social factors including the quality and quantity of social relationships. They cite those who experienced
3. an increased sense of connectedness during the pandemic compared to before reported increase in life
4. satisfaction (Okabe-Miyamoto & Lyubomirsky, 2021).

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1. **Longitudinal *changes* within the pandemic: mental wellbeing.** Longitudinal studies comparing mental wellbeing
2. before and during the pandemic among university students in the UK are limited (Lemyre et al., 2023). Three
3. studies indicated a substantial decrease in mental wellbeing at the beginning of the pandemic (Evans et al.,
4. 2021; Savage et al., 2020, 2021). This seems to reflect the brusque and unprecedented changes to daily life in
5. the early phase of the pandemic. Encouragingly, in our study, one year later, we observed over the next six
6. months an overall increase in mental wellbeing scores between T1 and T2. The improvement conveys student’s
7. positive adjustment and the easing of pandemic restriction. Our results indicate that, with time, students
8. adjusted and suggests the long-term mental wellbeing impacts may be less severe than feared based on early

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1. pandemic studies. As with other longitudinal studies of major disaster events, while initial shock provokes
2. significant distress in populations, data shows substantial resilience in people with time (Bonanno, 2004). Of
3. note here, while seasonality effects cannot be discounted in our study given the six month period between T1
4. and T2, we observed an increase in mental wellbeing in the fall compared to the spring, contrary to the well
5. documented seasonality increase in depression symptoms in the fall/winter period in the northern hemisphere
6. (Harmatz et al., 2000). Bennett et al., (2022) observed a comparable proportion of low mental wellbeing in
7. spring 2021 (56%) as in our sample at T1 (54%). Results from the Student COVID-19 Insight Survey also indicated
8. an upward trend in wellbeing from November 2020 to November 2021 (Office for National Statistics, 2021).

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1. Similar trends in adjustments are seen in the UK general population across large longitudinal survey using
2. representative samples, with increases in mental distress scores observed early into the pandemic compared to
3. before (Aknin et al., 2022; Pierce et al., 2020), particularly among young adults (Banks & Xu, 2020) and
4. decreases in daily happiness and positive affect (Fujiwara et al., 2020). Still, improvements were observed in
5. psychological distress later in the year (Fancourt et al., 2021; Stroud & Gutman, 2021).

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1. Prior diagnosis of mental health conditions did carry significantly lower mental wellbeing at both time points in
2. our sample. Similar evidence is seen in UK students in Bennett et al., (2022) and in Chen & Lucock., (2022).
3. Promisingly, however, in our sample these individuals also showed an improvement in mental wellbeing over

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1. time, as noted in a Canadian university study (Hamza et al., 2021). Similar findings are seen in the UK population,
2. where those with a pre-existing mental health condition suffered from worse mental health and mental
3. wellbeing (O’Connor et al., 2020; Stroud & Gutman, 2021) but still experienced amelioration over time (Fancourt
4. et al., 2021).

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1. **Protective factors for mental wellbeing within the pandemic.** Our second objective was to examine whether
2. positive factors of mental wellbeing changed as the pandemic evolved. At T1, when England was still socially
3. restricted and indoor household mixing was not allowed, positive correlates of mental wellbeing included

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1. physical activity, social support and no prior history of mental health diagnosis. The contribution of greenspace
2. use as conduits for physical and social activity was observed in intermediary steps of the hierarchical
3. regressions. At T2, when measures were less restrictive and university settings were open, positive factors for
4. mental wellbeing included group membership, social support and no history of mental health diagnosis. This
5. indicates that (a) different protective factors were important at various time points, but social support was
6. critical throughout the pandemic, (b) when social isolation was prominent (T1), use of greenspace and physical
7. activity had a greater importance for mental wellbeing, and (c) in times when face-to-face socialization was
8. permitted (T2), group membership took on its important role. These findings showcase ways in which wellbeing-
9. promoting measures and messaging can be tailored to mitigate the unintended consequences of the restrictions

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1. of the pandemic. When closures of social settings and quarantine requirements lead to isolation and negative
2. wellbeing outcomes, emphasis could have been swiftly placed on encouraging use of outdoor greenspaces as
3. safe locations for distanced socialization and physical activity. Calls for physical distancing must be accompanied
4. by calls to stay in contact by other means – safely. While experts advocated for parks to remain open in the UK
5. (McCunn, 2021), governments and universities intermittently restricted access to parks and natural spaces.
6. Based on our evidence, more should be done to ensure access to greenspaces in times of social isolation as it

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7 contributes to mental wellbeing.

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1. **Predictors of *changes* in mental wellbeing across the pandemic.** Lastly, we examined the associations between
2. predictors and changes in mental wellbeing. In our regression analysis controlling for baseline wellbeing, group
3. membership and social support were the main predictors significantly related to *increases* in mental wellbeing
4. over time, highlighting the positive role of social connectedness. Results also suggest mental wellbeing at T2 did
5. not further relate to COVID-19 experiences, as if students had adapted to the pandemic circumstances.

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## Implications

1. Higher education settings are unique environments that play an integral role in the development of young
2. adults, and for many, comprise educational, social and residential facets of life (Burns et al., 2020). In the UK,
3. universities have generally accepted a ‘*duty of care*’ towards the health and welfare of their students (Hubble &
4. Bolton, 2020). Examining how students fared during the pandemic and identifying protective factors which
5. favour wellbeing is of crucial importance. In addition to current provisions, based on our study and others, we
6. call upon higher education settings to bolster mental wellbeing promoting advice that encourages personal
7. agency of modifiable behaviours towards increased social connectedness and physical activity. We suggest this

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25 may be done by promoting the use of outdoor greenspace. We see this avenue as relevant during the pandemic,

1. and beyond. New ‘whole university approach’ initiatives, such as the 2019 ‘University Mental Health Charter’,
2. seek to encourage the development of mentally healthy universities, shifting the focus away from solely
3. provision of services, towards considerations of the impact of the environment as a whole (Universities UK,
4. 2018, 2020). These initiatives provide a framework to underscore the role of social and natural environment in
5. fostering wellbeing for students. Universities should concretely facilitate and actively encourage students to
6. engage with others and with nature (Hughes & Spanner, 2019), as per our significant results on socialization and
7. natural spaces.

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## Strengths and limitations

1. Our study adds to the existing literature on wellbeing of university students in England during the pandemic,
2. notably by making use of a longitudinal design, looking at a later time frame within the pandemic, and
3. investigating the contribution of social connectedness and outdoor greenspace use. We used a validated
4. instrument for our core outcome (WEMWBS), published indicators as covariates, and our sample size was
5. comparable to other longitudinal pandemic studies among students (Lemyre et al., 2023). Our sample was also
6. broadly similar to the higher education population of England (Higher Education Statistics Agency, 2022; Insight
7. Network, 2020). Of course, limitations remain. Our study was observational and exploratory. It relied on a non-

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1. probabilistic sample of students opting-in to participate, limiting the generalizability of findings. Replication with
2. a larger nationally representative sample would increase the reliability and generalizability of findings, allow for
3. more statistical procedures and confer greater statistical power. Additional waves of data would also be
4. informative for long term wellbeing trajectories. Although our attrition rate was lower than often observed in
5. similar studies, and dropouts did not differ in terms of mental wellbeing, it remains a risk of selection bias.
6. Further, this study did not assess the full range of factors related to mental wellbeing; it is possible unobserved
7. variables played a role in the observed changes. Lastly, as this was not an experimental design causation cannot
8. be ascertained; interpretation shall remain prudent.

# 3 Conclusion

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1. Our study adds to the current literature by improving our understanding of the student experience and mental
2. wellbeing trajectories in later phases of the pandemic. We aimed to help inform institution’s approach to mental
3. wellbeing promotion – for present and future times. Encouragingly, we found a significant increase in overall
4. mental wellbeing over six months. This positive trend suggests students adjusted, adapted their behaviours to
5. context, and suggests the long-term mental wellbeing impacts of the pandemic may be less severe than
6. expected based on early pandemic research. Findings revealed social support played a critical protective role in
7. mental wellbeing. We conclude that wellbeing-promoting messaging must be tailored in times of crisis to fit the

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1. context on the ground. Greenspaces facilitate distanced socialization and physical activity and should be
2. promoted as such.

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## Acknowledgments

1. [See title page]

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## Funding information

1. [See title page]

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## Conflict of interests

1. [See title page]

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## Ethics statement

1. [See title page]

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1. **Data availability statement**
2. Due to the sensitive nature of the information, risk for participant identification by subgroups and ethics

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32 approval constraints, raw data cannot be shared.

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## ORCID

1. [See title page]

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## Tables

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1. **Table 1**
2. *Baseline characteristics of sample of university students*
3. **Longitudinal Sample**

10 **N = 161 % / Mean (SD)**

1. **Age**

12 Range 18 - 34 161 22.6 (3.88)

13 **Sex at birth**

Females

Males

14 115 71.4%

15 46 28.6%

|  |  |  |
| --- | --- | --- |
| **Gender identity** |  | |
| Women | 108 | 67.1% |
| Man | 43 | 26.7% |
| Gender diverse | 10 | 6.2% |
| **Sexual orientation a** |  |  |
| Heterosexual | 107 | 71.8% |
| Non heterosexual | 42 | 28.2% |
| **Ethnicity a**  White | 119 | 76.8% |
| Non white | 36 | 23.2% |
| **Study level a** |  |  |
| Undergraduate | 96 | 60.4% |
| Postgraduate | 63 | 39.6% |
| **Student status** |  |  |
| Full-time | 159 | 98.8% |
| Part-time | 2 | 1.2% |
| **Accommodation type** |  |  |
| University | 67 | 41.6% |
| Private | 94 | 58.4% |
| **Living arrangement a** |  |  |
| Living alone | 14 | 8.7% |
| Living with someone | 147 | 91.3% |
| **Prior mental health diagnosis** |  |  |
| Yes | 46 | 29.5% |
| No | 110 | 70.5% |

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1. a Dichotomous version of variable presented

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1. **Table 2**
2. *Longitudinal within-subject comparisons six months apart during the COVID-19 pandemic*

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**N**

**T1: April-May 2021**

**Mean (SD) Range**

**T2: Nov-Dec 2021**

**Mean (SD) Range**

**Paired-sample *t* test**

***t* statistic**

***p* value Effect size a**

**COVID-19 experiences**

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10 **COVID-19 fear** 153 14.3 (5.05) 7 - 27 13.1 (4.84) 7 - 32 -3.95 **< 0.001\*\*\*** -0.32

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1. **COVID-19 infection worry** 154 12.9 (4.02) 5 - 24 12.2 (3.56) 5 - 21 -1.83 0.07 n/a

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2.5 (1.06)

156

3.2 (1.22) 0 - 5

2.8 (1.17)

**Mental wellbeing**

**Lifestyle behaviours**

154

2.6 (1.05) 0 - 4

**WEMWBS**

154

42.0 (8.87) 14 - 65

43.5 (8.69) 20 - 68

2.59

**0.01\*\***

0.21

\*\*\* (p ≤ 0.001); \*\* (0.001 < p ≤ 0.01); \* (0.01 < p ≤ 0.05)

a Effect Size Cohen's *d* for paired *t-*test: Small (|ES| = 0.2); Medium (|ES| = 0.5); Large (|ES| = 0.8)

14 **COVID-19 NPI protective** 152 34.3 (5.82) 15 - 45 28.8 (6.66) 15 - 45 -13.84 **< 0.001\*\*\*** -1.12

1. **behaviours**

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1. **Physical activity frequency**

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1. **Greenspace use frequency**

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0 - 4 -0.80 0.42 n/a

0 - 5 -4.28 **< 0.001\*\*\*** -0.34

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1. **Table 3**
2. *Hierarchical regression models at T1 in spring 2021 (n = 144)*
3. **Step 1 Step 2 Step 3 Step 4 Step 5**
4. Sociodemographic controls COVID-19 experiences Lifestyle
5. behaviours

Social connectedness No prior mental health diagnosis

1. **Outcome: WEMWBS T1 B (SE) β B (SE) β B (SE) β B (SE) β B (SE) β**

Age

Gender (Men)

Sexual orientation (Heterosexual)

COVID-19 fear COVID-19 NPI

protective behaviors

Physical activity Greenspace use Group membership Social Support

0.40(0.19)

1.28(1.71)

**0.17\***

0.06

0.41(0.19) **0.18\***

-0.03(1.81) 0.00

0.41(0.19) **0.18\***

1.36(1.79) 0.07

0.45(0.18) **0.19\***

1.44(1.72) 0.07

0.50(0.17)

0.47(1.60)

**0.21\*\***

0.02

2.20(1.73)

0.11

2.33(1.71)

0.11

0.67(1.71)

0.03

-0.17(1.66)

-0.01

-2.07(1.58)

-0.10

-0.30(0.16)

-0.17

-0.28(0.16)

-0.16

-0.21(0.15)

-0.12

-0.14(0.14)

-0.08

-0.07(0.15)

-0.04

-0.04(0.15)

-0.02

-0.07(0.14)

-0.04

-0.04(0.13)

-0.02

1.48(0.82)

1.36(0.69)

0.17

**0.18\***

1.73(0.80)

0.68(0.70)

1.75(1.68)

7.69(2.35)

**0.19\***

0.09

0.08

**0.26\*\***

No prior mental health diagnosis

*Adjusted R2*

*Δ Adjusted R2*

1.67(0.74)

0.59(0.64)

1.75(1.55)

5.77(2.20)

7.51(1.53)

0.30\*\*\*

0.12\*\*\*

**0.19\***

0.08

0.08

**0.20\*\***

**0.38\*\*\***

0.03

0.05\*

0.02

0.12\*\*\*

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0.18\*\*\*

0.06\*\*

\*\*\* (p ≤ 0.001); \*\* (0.001 < p ≤ 0.01); \* (0.01 < p ≤ 0.05)

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1. **Table 4**
2. *Hierarchical regression models at T2 in fall 2021 (n = 135)*
3. **Step 1 Step 2 Step 3 Step 4 Step 5**
4. Sociodemographic controls COVID-19 experiences Lifestyle
5. behaviours

Social connectedness No prior mental health diagnosis

1. **Outcome: WEMWBS T2 B (SE) β B (SE) β B (SE) β B (SE) β B (SE) β**
2. Age 0.20(0.20) 0.09 0.32(0.20) 0.14 0.30(0.21) 0.13 0.14(0.19) 0.05 0.21(0.18) 0.09

Gender (Men)

Sexual orientation (Heterosexual)

COVID-19 fear COVID-19 NPI

protective behaviors

Physical activity Greenspace use Group membership Social Support

0.14(1.77)

0.01

-0.91(1.83) -0.04

-0.67(1.85) -0.03

-0.79(1.68) -0.04

-1.53(1.60)

-0.08

4.02(1.79)

**0.20\***

3.99(1.77)

**0.20\***

3.74(1.78)

**0.18\***

2.96(1.62)

0.15

1.46(1.57)

0.07

-0.02(0.19)

-0.01

0.00(0.19)

0.00

0.07(0.17)

0.04

0.16(0.16)

0.08

-0.28(0.13)

**-0.21\***

-0.27(0.13)

**-0.20\***

-0.19(0.12)

-0.15

-0.22(0.12)

-0.16

0.68(0.80)

0.30(0.77)

0.08

0.04

-0.18(0.74)

0.27(0.70)

5.73(1.89)

9.96(2.16)

-0.02

0.03

**0.24\*\***

**0.37\*\*\***

No prior mental health diagnosis

*Adjusted R2*

*Δ Adjusted R2*

-0.39(0.70)

0.16(0.66)

5.84(1.79)

8.18(2.09)

6.20(1.52)

0.31\*\*\*

0.09\*\*\*

-0.05

0.02

**0.25\*\***

**0.30\*\*\***

**0.32\*\*\***

0.03

0.05\*\*

0.02

0.05

0.00

0.22\*\*\*

0.17\*\*\*

\*\*\* (p ≤ 0.001); \*\* (0.001 < p ≤ 0.01); \* (0.01 < p ≤ 0.05)

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1. **Table 5**
2. *Multiple longitudinal regression of mental wellbeing at T2 (n = 151)*

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|  |  |  |
| --- | --- | --- |
| **Outcome: WEMWBS T2** | **B (SE)** | **β** |
| T1 WEMWBS | 0.56(0.06) | **0.57\*\*\*** |
| T2 COVID-19 fear | -0.02(0.13) | -0.01 |
| T2 COVID-19 NPI  protective behaviors | -0.08(0.09) | -0.06 |
| T2 Physical activity | -0.59(0.56) | -0.07 |
| T2 Greenspace use | 0.39(0.51) | 0.05 |
| T2 Group membership | 3.58(1.42) | **0.15\*** |
| T2 Social Support | 5.08(1.79) | **0.18\*\*** |

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\*\*\* (p ≤ 0.001); \*\* (0.001 < p ≤ 0.01); \* (0.01 < p ≤ 0.05)

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## 3 Appendix A. Supplementary data

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5 **Figure A.1:** Flow chart of participant inclusion in analysis

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7 **Figure A.2:** Recall-based lifestyle behaviour changes between T1 and pre-pandemic times

8 **Table A.1:** Correlations

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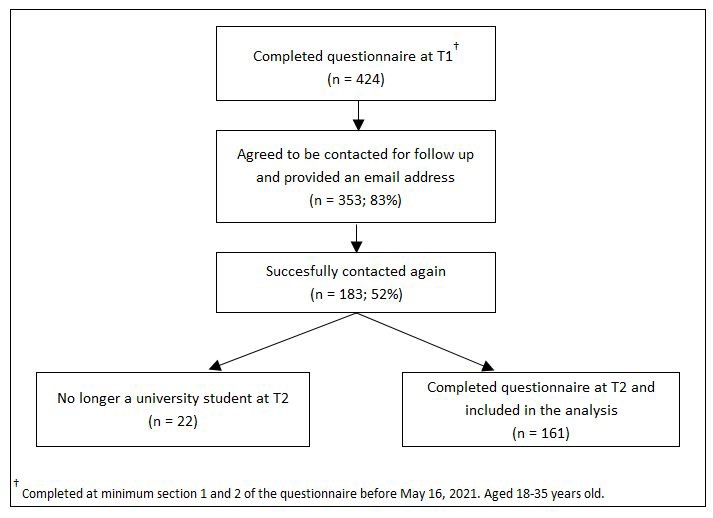
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3 **Figure A.1 Flow chart of participant inclusion in analysis**

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35 **Appendix Figure A. 1:** Flow chart of participant inclusion in analysis

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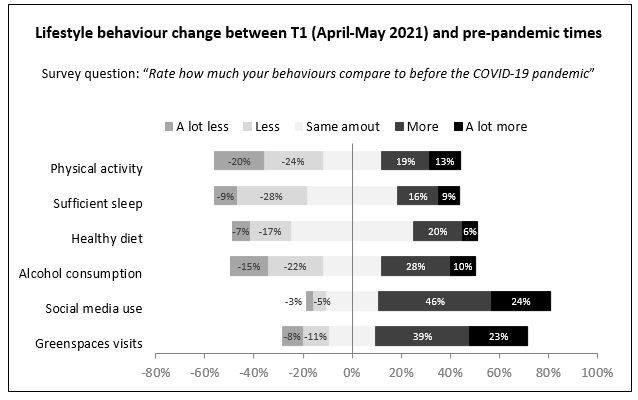
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3 **Figure A.2 Recall-based lifestyle behaviour changes between T1 and pre-pandemic times**

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32 **Appendix Figure A.2:** Recall-based lifestyle behaviour changes between T1 and pre-pandemic times for

33 comparison with other studies

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7 **Table A.1**

**Table A.1**: **Correlations**

8 *Correlation matrix between outcome and key predictors at T1 and T2 a*

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| **1** | | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| **Upper triangle: T2 (Nov-Dec 2021)** | | | | | | | | |
| 1. WEMWBS | 1 | -.13 | **-.19\*** | .12 | .14 | **.28\*\*\*** | **.37\*\*\*** | **.37\*\*\*** |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 12 2. COVID-19 fear | **-.20\*** | 1 | **.45\*\*\*** | -.10 | -.15 | -.04 | **-.19\*** | **-.17\*** |
| 13 3. COVID-19 NPI protective behaviours | -.09 | **.42\*\*\*** | 1 | -.10 | **-.16\*** | **-.17\*** | -.07 | -.08 |
| 14 4. Physical activity frequency | **.23\*\*** | .05 | .09 | 1 | **.43\*\*\*** | .12 | **.22\*\*** | **.18\*** |
| 15 5. Greenspace use frequency | **.29\*\*\*** | -.05 | -.14 | **.44\*\*\*** | 1 | .04 | **.17\*** | 0.16 |
| 16 6. Group membership | **.21\*\*** | -.05 | -.04 | .12 | **.27\*\*\*** | 1 | .00 | .00 |
| 17 7. Social Support | **.30\*\*\*** | -.10 | -.04 | .01 | **.24\*\*** | **.16\*** | 1 | **.28\*\*\*** |
| 18 8. No prior mental health diagnosis | **.42\*\*\*** | **-.17\*** | -.13 | .05 | .12 | .06 | **.21\*\*** | 1 |

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21 \*\*\* (p ≤ 0.001); \*\* ( 0.001 < p ≤ 0.01); \* (0.01 < p ≤ 0.05)

22 a Lower triangle for T1, upper triangle for T2

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**Lower triangle: T1 (April-May 2021)**

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