Green–blue space exposure changes and impact on individual-level well-being and mental health: a population-wide dynamic longitudinal panel study with linked survey data

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Scientific summary

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Scientific summary

Background

Cross-sectional evidence suggests that living close to and spending time in and around green and blue spaces (GBS, e.g. parks, gardens, ponds, lakes, rivers) is associated with higher levels of well-being and fewer mental health problems. Some of these benefits could result from living near GBS; others (e.g. physical activity) are attributed to using GBS. There are few longitudinal studies examining whether changes in GBS affect subsequent mental health. Existing studies have largely had small cohorts, assessed change over a short time, did not investigate socioeconomic inequalities in effects and neglected to consider that some health benefits depend on using GBS rather than simple exposure.

Objectives

We examined the research questions:

1. Is a greater residential exposure and access to GBS associated with the likelihood of seeking help for a common mental health disorder (CMD) in general practice?
2. Is the association between exposure, or access to, GBS and seeking help for a CMD modified by socioeconomic disadvantage and moving home?
3. Is a greater residential exposure associated with the likelihood of using general practice services?
4. Is greater residential GBS exposure and access to GBS associated with higher subjective well-being or a lower likelihood of seeking help for CMD, and does intentional use of GBS for leisure mediate these associations?
5. Are associations between residential GBS exposure and access to GBS and use and subjective well-being mediated by walking-specific physical activity and modified by socioeconomic disadvantage?

Methods

We used a dynamic longitudinal panel study design to retrospectively examine natural and non-random variation in GBS exposure during an 11-year period, with individual linkage to survey responses.

Data sources

We constructed an electronic cohort of the population of Wales using data from the Welsh Demographic Service Dataset. Household-level ambient greenness was determined from satellite imagery, access to GBS from planning records, CMD and service use from Welsh Longitudinal General Practice Dataset (WLGPD) and for a subgroup, well-being and behaviour responses to the National Survey for Wales (NSW, 2016/17 and 2018/19). Data are held in the Secure Anonymised Information Linkage (SAIL) databank.

Inclusion criteria

The cohort included everyone aged 16 years and over registered with a general practitioner (GP) providing patient records to the SAIL databank between January 2008 and October 2019 ('the study period'). Those not registered with an appropriate GP, not having a Welsh residential address between January 2008 and October 2019, and not having sex/week of birth recorded were excluded from the study sample.

Exposures

- Our primary environmental exposure was ambient greenness, measured yearly (2008–19) by mean enhanced vegetation index (EVI) averaged over a 300 m circular buffer centred on each residence.
- Our secondary environmental exposure was the potential for an individual to access GBS along paths/roads within 1600 m of each home, modelled for 2018. We captured changes only when individuals moved home. For research questions 1–3, GBS access was quantified by the number of potentially accessible GBS. For research questions 4–5, access was quantified as the proximity to the nearest GBS.

Outcome measures

- For research questions 1–3, our primary outcome was seeking help for CMD in general practice, identified from practice records using a validated algorithm. Our secondary outcome was the quarterly count of general practice events.
- For research questions 4 and 5, our primary outcome was subjective well-being, measured by the Warwick–Edinburgh Mental Well-being Scale (WEMWBS) in the NSW. Secondary outcomes were life satisfaction (NSW) and seeking help for CMD in general practice. Self-reported time outdoors on recreational visits to GBS in Wales and walking-specific physical activity were identified (NSW).

Statistical analysis

Research questions 1–3 were addressed using complementary approaches:

- We first evaluated associations between cumulative EVI exposure and seeking help for CMD in general practice using multivariate logistic regression. Follow-up stopped when help was first sought for CMD or at the end of the study period. This time aggregated design allowed us to consider environmental exposure prior to seeking help for CMD in general practice and included differences between people. We conducted stratified analyses according to area-level deprivation (Welsh Index of Multiple Deprivation, WIMD) quintiles, home moves (none/one/more than one), history of seeking care for CMD in general practice (before January 2008) and urban-rural home location.
- Next, we assessed associations between longitudinal change in GBS exposures for the same individuals, and their subsequent likelihood of seeking help for CMD (primary outcome) using multivariate logistic regression. For the association with general practice services use (secondary outcome) we used Poisson regression. We used a panel design with a multilevel model structure (quarterly observations nested within individuals). We accounted for clustering of observations over time (using random effects), and unbalanced data (number of observations varying for individuals). Change in GBS exposure was modelled as a continuous variable relative to previous time periods. For people who did not move home, we modelled EVI change categories to examine in situ exposure changes. Stratified analyses were conducted for quintiles of WIMD and number of home moves.

For research questions 4–5 we assessed whether GBS exposures were related to WEMWBS, life satisfaction and seeking help for CMD, and whether there was moderation by socioeconomic disadvantage. We examined whether the association between GBS exposures and WEMWBS, life satisfaction and seeking help for CMD, were mediated by time spent outdoors. Generalised additive models were used to identify any non-linear associations and inform subsequent generalised linear regression. When predicting WEMWBS, linear and quadratic terms for EVI were included and proximity to nearest GBS was categorised. For seeking help for CMD, EVI was categorised, and proximity was continuous. To assess moderation by socioeconomic disadvantage, we included interactions between material deprivation and the GBS exposures.

Results

The cohort included 2,801,483 individuals (99,682,902 observations). A total of 816,242 individuals (29.1%) sought help for CMD from their general practice at least once in the study period.

Research question 1: Is a greater residential exposure and access to GBS associated with the likelihood of seeking health for CMDs in general practice?

People who lived in homes surrounded by more ambient greenness (+0.1 EVI) were associated with 20% lower odds of seeking help for CMD in general practice [adjusted odds ratio (AOR) 0.80, 95% confidence interval (CI) 0.80 to 0.81]. More potentially accessible GBS (equivalent to 236 more GBS) were associated with 7% lower odds of seeking help for CMD (AOR 0.93, 95% CI 0.93 to 0.93). Every additional 360 m (0.1 unit) to the nearest GBS was associated with 5% higher odds of seeking help for CMD (AOR 1.05, 95% CI 1.04 to 1.05).

People experiencing an increase of 0.1 mean EVI was not associated with seeking help for CMD in general practice (exposure change relative to: previous quarter/year/baseline AOR 1.00, 95% CI 1.00 to 1.00). Among the 1,611,581 people who did not move home (57.5% of the cohort), increases or decreases of ≥ 0.15 EVI relative to baseline were not associated with seeking help for CMD (AOR for ≥ +0.15 EVI 1.00, 95% CI 0.99 to 1.00; AOR for ≥ −0.15 EVI 1.00, 95% CI 1.00 to 1.01). Among those who moved home at least once, an increase in the number of potentially accessible GBS was not associated with seeking help for CMD in general practice (GBS increase relative to previous quarter/year/baseline: AOR 1.00, 95% CI 1.00 to 1.00).

Research question 2: Is the association between exposure, or access to, GBS and seeking help for a CMD modified by socioeconomic disadvantage and moving home?

Living in a home with greater EVI (+0.1) and more accessible GBS (+236) was associated with lower odds of seeking help for CMD in general practice in all deprivation quintiles and whether people moved. The odds of seeking help were lower for those who did not move (AOR non-movers 0.77, 95% CI 0.77 to 0.78; AOR moved > once 0.92, 95% CI 0.91 to 0.93).

There was no evidence that EVI or GBS changes were associated with seeking help for a CMD for people living in either the most or least deprived urban areas. An increase of 0.1 mean EVI (relative to baseline) was associated with slightly lower odds of seeking help for CMD for people who moved home more than once (AOR 0.99, 95% CI 0.99 to 0.99) but not for those who moved once or had not moved.

Association between different GBS exposures and seeking help for CMD in general practice were modified by urban–rural home location and a history of seeking help for CMD. Greater EVI was associated with lower odds of seeking help for a CMD for those living in rural areas (AOR 0.59, 95% CI 0.58 to 0.59) compared with urban areas (AOR 0.85, 95% CI 0.84 to 0.85). More potentially accessible GBS were only associated with lower odds of seeking help for CMD for those living in urban areas (AOR 0.89, 95% CI 0.89 to 0.89). In rural areas more GBS access was associated with higher odds of seeking help for CMD (AOR 1.10, 95% CI 1.08 to 1.12). More ambient greenness (+0.1 EVI) was associated with lower odds of seeking help for a CMD for those who had historically sought help for CMD (before January 2008) than people who had not (AOR 0.68 vs. 0.84).

Research question 3: Is a greater residential exposure associated with the likelihood of using GP services?

There was no evidence that an increase in mean EVI was associated with the number of general practice event days/quarter (adjusted incidence rate ratio relative to baseline: 1.00, 95% CI 1.00 to 1.00).

Research question 4: Is greater residential GBS exposure and access to GBS associated with higher subjective well-being, or a lower likelihood of seeking help for CMD in general practice, and are these associations mediated by intentional use of GBS for leisure?

Among NSW respondents with outcome measures (n = 5971) EVI was significantly related to well-being as measured by WEMWBS with a U-shaped relationship (linear regression; EVI −10.15, 95% CI −17.13 to −3.17; EVI^2 12.49, 95% CI 3.02 to 21.97) and weekly time outdoors (linear relationship; EVI 43.41, 95% CI 6.85 to 79.97). Time outdoors was significantly positively related to WEMWBS [time outdoors (hours) 0.88, 95% CI 0.53 to 1.24, time outdoors $(hours)^2$ −0.06, 95% CI −0.11 to −0.01] and life

satisfaction [linear relationship; time outdoors (hours) 0.06, 95% CI 0.04 to 0.07]. There was no evidence that time outdoors mediated the relationship between EVI and WEMWBS/life satisfaction. EVI was not associated with CMD (EVI 0.4 to 0.8 vs. < 0.2, AOR 1.06, 95% CI 0.80 to 1.42) but increased time outdoors was significantly associated with reduced odds of seeking help for CMD (AOR 0.96, 95% CI 0.93 to 0.99). Proximity of nearest GBS was not related to WEMWBS/CMD/life satisfaction.

Research question 5: Are associations between residential GBS exposure and access to GBS and use, and subjective well-being mediated by walking-specific physical activity and modified by socioeconomic disadvantage?

Prerequisite conditions were met for potential mediation, but the time outdoors-WEMWBS coefficient was not substantially attenuated when adding walking physical activity (standardised time outdoors beta reduction: 0.21 to 0.19, standardised time outdoors^2 beta reduction 0). However, the time outdoors-life satisfaction coefficient was partly attenuated when adding walking physical activity (beta reduction 0.07 to 0.05). The 95% CI before and after addition of walking physical activity overlapped, evidencing that walking physical activity partially mediated the relationship between time outdoors and life satisfaction.

We found no evidence that material deprivation modifies the association between EVI/GBS proximity and WEMWBS/life satisfaction (WEMWBS, EVI × in material deprivation vs. EVI × not in material deprivation: 3.24, 95% CI −16.90 to 23.38; EVI^2 × in material deprivation vs. EVI^2 × not in material deprivation: −5.31, 95% CI −33.48 to 22.85). For those in material deprivation, the association between leisure time outdoors and both WEMWBS and life satisfaction was stronger compared with those not in material deprivation up to ~4 hours leisure time outdoors/week (7 + hours for life satisfaction) (WEMWBS: time outdoors × in material deprivation: 1.41, 95% CI 0.39 to 2.43; time outdoors^2 × in material deprivation −0.18, 95% CI −0.33 to −0.04; life satisfaction: time outdoors × in material deprivation: 0.08, 95% CI 0.03 to 0.13).

Increasing time outdoors had a greater benefit (higher WEMWBS/better life satisfaction) although well-being remained generally lower.

Public involvement

We co-created our study analysis plans and interpreted our findings with stakeholders. We successfully engaged policy makers but were less successful with third-sector mental health stakeholder engagement on our steering group. This was due to staff changes restricting opportunities for building relationships and increasing pressures on those working in mental health due to the COVID-19 pandemic.

Conclusions

Despite some limitations due to a lack of EVI variation in Wales, the findings from our study considerably extend the evidence on the association between mental health/well-being and residential GBS/visits. Particularly important are our findings of a disproportionate well-being benefit of time outdoors for individuals living in material deprivation.

We saw an increase in mental health help-seeking behaviour with greater EVI for people in the most deprived rural areas, potentially highlighting isolation as an issue. Conversely, for those with an historical CMD, greater EVI may reduce mental health inequalities.

Neighbourhood greenness and visiting GBS were both related to better well-being, but the lack of mediation suggests different mechanisms.

There is a need to understand better where to prioritise investment for equitable availability of GBS or the targeted delivery of interventions to reduce health inequalities.

Research recommendations

More sophisticated methods are needed to spatially impute changes in GBS recorded in planning data; current methods are restricted by data capture timelines.

1. The individual-level linked survey and routine health data can provide baseline data for future prospective longitudinal analysis, and more sophisticated studies of mediation and moderation in environment-health research.
2. Consent for individual level data linkage should be considered for all surveys; the depth of behavioural insight nested within routinely collected data for a population provides invaluable insights into explanatory mechanisms.
3. Further analyses could investigate different 'settling in' periods following moving home, capturing outcomes at the time of the move and subsequently.
4. The dataset could be extended to investigate maternal mental health outcomes and general outcomes for children.

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