The environment a young person grows up in is associated with their mental health: A nationwide geospatial study using the integrated data infrastructure, New Zealand.

HOBBS, Matthew, BOWDEN, N, MAREK, L, WIKI, J, KOKAUA, J, THEODORE, R, RUHE, T, BODEN, J, THABREW, H, HETRICK, S and MILNE, B

Social Science & Medicine 326 (2023) 115893

Contents lists available at ScienceDirect

Social Science & Medicine

journal homepage: www.elsevier.com/locate/socscimed

The environment a young person grows up in is associated with their mental health: A nationwide geospatial study using the integrated data infrastructure, New Zealand

Hobbs M [a,b,*,1], Bowden N [c,1], Marek L [b], Wiki J [b], Kokaua J [d], Theodore R [e], Ruhe T [d], Boden J [f], Thabrew H [g], Hetrick S [g], Milne B [h]

[a] Faculty of Health, University of Canterbury, Christchurch, Canterbury, New Zealand
[b] GeoHealth Laboratory, Geospatial Research Institute, University of Canterbury, Christchurch, Canterbury, New Zealand
[c] Department of Women's and Children's Health, University of Otago, Dunedin, New Zealand
[d] Va'a O Tautai - Centre for Pacific Health, Health Sciences, University of Otago, Dunedin, New Zealand
[e] National Centre for Lifecourse Research, University of Otago, Dunedin, New Zealand
[f] Christchurch Health and Development Study, Department of Psychological Medicine, University of Otago Christchurch, New Zealand
[g] The Werry Centre, Department of Psychological Medicine, University of Auckland, Auckland, New Zealand
[h] Centre of Methods and Policy Application in the Social Sciences, University of Auckland, Auckland, New Zealand

ARTICLE INFO

Handling Editor: Susan J. Elliott

Keywords:
Integrated data infrastructure
Mental health
Geospatial
Geographic information systems
Environment
Healthy location index

ABSTRACT

Background: Mental health conditions often arise during adolescence, are multifaceted in aetiology, and may be related to the type of environment in which young people reside. This study used nationwide population-level data to investigate whether the environment a young person grows up in is associated with their mental health.
Method: Data were extracted from the Integrated Data Infrastructure (IDI), a large nationwide research repository, for 917,211 young people (aged 10–24 years) including sociodemographic and mental health data (i.e. emotional, behavioural, substance problems, and self-harm). Environmental data were sourced from the nationwide area-based Healthy Location Index (HLI), which has comprehensive data on the location of several health-constraining (i.e. fast-food outlets) and health-promoting features (i.e. physical activity facilities). Environments were classified as: i) health-promoting, ii) health-constraining, or iii) neither. Associations between the HLI and mental health were investigated using multi-level mixed effects logistic regression modelling.
Results: Overall, there was evidence of an association between the environment a young person resided in and their mental health. Young people residing in health-constraining environments had higher odds of any mental health condition (Adjusted Odds Ratio (AOR) = 1.020 [1.001, 1.040]) and any emotional condition (AOR = 1.037 [1.012, 1.062]). Young people residing in health-promoting environments had lower odds of substance problems (AOR = 0.950 [0.905, 0.997]). There were no significant effects of the environment on behavioural conditions.
Conclusion: Our study utilises a large national sample of almost one million young people to confirm the importance of environmental determinants for mental health. It is possible that leverage points for improving the mental health of young people, and reducing the burden to the health system of mental health, can be sought in upstream environmental based interventions.

1. Introduction

Mental health conditions account for approximately 16% of the global burden of disease for young people aged 10–19 years (World Health Organisation, 2019, 2020). Depression is also one of the leading causes of illness and disability among adolescents, and suicide is the third leading cause of death in adolescents aged 15–19 years (World Health Organisation, 2019, 2020). Moreover, mental health conditions

* Corresponding author. School of Health Sciences University of Canterbury, Christchurch, Canterbury, New Zealand
E-mail address: matt.hobbs@canterbury.ac.nz (H. M).
[1] Joint first authors.

https://doi.org/10.1016/j.socscimed.2023.115893
Received 30 October 2022; Received in revised form 19 March 2023; Accepted 6 April 2023
Available online 7 April 2023

often begin in young people and persist to adulthood (Copeland et al., 2015; Fergusson et al., 2005; Heidinger and Willson, 2019; Fergusson and Horwood, 2001; Moffitt et al., 2010). The consequences of poor mental health are burdensome including, poorer academic achievement (Fergusson et al., 1993), unemployment (Colman et al., 2009) and higher rates of criminality (Kjelsberg, 2002).

Mental health results from a complex interplay of factors including genetic, social, environmental, political and structural determinants (Bowler et al., 2010; Helbich, 2018). Despite this understanding of complex aetiology, interventions and policy persistently focus on downstream individualistic determinants (e.g. individual or family). However, it is known that proximal downstream factors, such as psychosocial stressors or behaviours, are greatly influenced by wider structural or environmental determinants (Dopp and Lantz, 2020; Shim and Compton, 2018). Little research has addressed these upstream determinants (e.g. infrastructural, environmental or policy-related) of mental health and other health conditions (Helbich, 2018; Dopp and Lantz, 2020; Nobles et al., 2021; Lakerveld and Mackenbach, 2017). However, research has highlighted that upstream factors can lead to significant sociodemographic patterning in attention-deficit/hyper activity disorder (ADHD) incidence, including under- and over-diagnosis (Layton et al., 2018). Other research supports this, demonstrating that moving to higher income communities leads to significantly fewer symptoms of anxiety, depression, and dependency (e.g. need to be near adults) in adolescent boys (Leventhal and Brooks-Gunn, 2003). Small changes in upstream factors that affect many people can result in large improvements in the mental health of a population because of a population-level shift in the distribution of risks, exposures and resources (Dopp and Lantz, 2020; Rose, 1985).

The influence of environmental features on population-level health outcomes is receiving increasing recognition in international research. For the purpose of this study, we define 'the environment' as relating to the geographical proximity of health-promoting (e.g. greenspaces) and health-constraining (e.g. alcohol outlets) features. Exposure to many of these environmental features has been identified as relevant to health, particularly mental health, including but not limited to air pollution (Manisalidis et al., 2020; Marek et al., 2018; Campbell et al., 2021), weather conditions (Hobbs et al., 2021a), and natural light (Bowler et al., 2010), as well as the location of fast-food or alcohol outlets, greenspaces (e.g. parks) (van den Berg et al., 2017; Van den Berg et al., 2015; Twohig-Bennett and Jones, 2018), bluespaces (i.e. rivers) (Britton et al., 2020) and physical activity facilities (i.e. leisure centres or playgrounds) (Mackenbach et al., 2014). Importantly, health-constraining environmental features, such as fast-food outlets (Black et al., 2014; Maguire et al., 1990–2008; Hobbs et al., 2021b), alcohol outlets (Pearce et al., 2008) or even air pollution (Hajat et al., 2015) are often disproportionately distributed across socioeconomic status, with hazards and health-constraining features of the environment being more prevalent in deprived areas. The impact of environmental factors on mental health was underscored in a recent prospective study where high-resolution pollution estimates at age 12 years were associated with increased odds of major depressive disorders at age 18, even after controlling for common risk factors (Roberts et al., 2019). Other nationwide longitudinal research of 900,000 Danish adults demonstrated a dose-response relationship such that children who grew up with the lowest levels of greenspace had up to 55% higher risk of developing a psychiatric disorder independent from effects of other known risk factors (Engemann et al., 2019). Plausible mechanisms linking the environment to mental health have also been identified. For instance, it is thought that a relationship between greenspace and mental health may be mediated through physical activity (van den Berg et al., 2017), enhanced cognition (Dadvand et al., 2015), an enhanced immune system (Hartig et al., 2007; Böbel et al., 2018; Rook, 2013) or social cohesion (Hartig et al., 2007). Moreover, factors within the environment such as the location of greenspaces, alcohol outlets or air pollution zones offer arguably more tangible interventions for policy to target.

It is plausible that environmental features act independently as well as simultaneously to influence mental health (Britton et al., 2018; Markevych et al., 2017). Previous research supports this notion demonstrating that environmental features co-locate or cluster in space where populations reside and work due to demand for such features (Wiki et al., 2018). Many studies have noted the importance of moving beyond considering isolated environmental factors alone, toward comprehensive metrics that model various aspects of the environment such as the Healthy Location Index (HLI) in New Zealand or the Access to Healthy Assets and Hazards' for Great Britain (Macdonald et al., 2018; Hobbs et al., 2019; Green et al., 2018). This is primarily achieved through the development of environmental indices that consider the accumulation or relative proportion of multiple dimensions of the environment (Sushil et al., 2017; Pearson et al., 2013; Sadler et al., 2019). Such approaches allow for the inclusion of both health-promoting and health-constraining features and can provide deeper insight into the influence of the environment on population health outcomes. Much of the current research in this field focuses on socioeconomic factors (Maguire et al., 1990–2008; Macdonald et al., 2018; Macintyre et al., 2008) or physical health outcomes such as obesity (Mason et al., 2020; Feng, 2010; Hobbs et al., 2017a), with less research focusing on the influence of clusters of environmental determinants on mental health in young people (Helbich, 2018; Helbich et al., 2018). Moreover, studies often use small or restricted samples of young people only. When considered together, these limitations indicate a critical gap in the current literature. Consequently, this study aims to use address data to identify a young person's (aged 10–24 years) exposure to health-promoting and health-constraining environmental features at a population level and investigate subsequent associations with the prevalence of mental health conditions including emotional, behavioural, substance problems, and self-harm. Such research forms a basis on which to better understand spatial associations and potentially formulate policy directed toward environmental influences on mental health. We hypothesise that residing in an environment with more health-promoting features and fewer health-constraining features will be beneficial for a young person's mental health.

2. Methods

2.1. Integrated data infrastructure

The primary source of data for this study was the Integrated Data Infrastructure (IDI), a large whole-population research database, curated by Statistics New Zealand that contains a wide range of administrative and survey data. Examples of government agency data include health, education, tax, births, deaths, and marriage information that are typically available from the 1990s onward (Milne et al., 2019). These data are probabilistically linked using full name, sex, and date of birth at the individual level by Statistics New Zealand (Kvalsvig et al., 2019). The data are de-identified with information such as name and address removed. Data are available for research projects deemed to be for the public good. Strict protocols and approval processes are in place to both access IDI data and release results (Statistics New Zealand, 2017).

2.2. Study design

This was a nationwide cross-sectional geospatial study. It used mental health data from the IDI and geospatial data on health-constraining and health-promoting environments (see section 2.5 below). This study was approved by the University of Otago Human Research Ethics Committee (reference: HD17/004) and was reviewed as a "Minimal Risk Health Research - Audit and Audit related studies" proposal. Statistics New Zealand approved access to the IDI.

2.3. Participants and settings

The participants were a national cohort of New Zealand young people (10–24 years old) in the 2018 calendar year. We chose this age range as a focus of this work is youth (24 and under; hence the upper age limit) and the lower limit was chosen because among those under 10 years of age, the mental health outcomes were infrequent. In addition, we chose the year 2018 as our research question was not to analyse temporal trends at this point and it was also to ensure there was the best temporal alignment with our geospatial data. This was determined using the existing Gibb et al. (2016) method for identifying the New Zealand estimated resident population (ERP) using the IDI and aligns with 2018 environmental data. To be included in the IDI-ERP, individuals are required to be alive and living in New Zealand and to have engaged with key government agencies within the previous two years such as health, education, and taxation. The resident populations constructed using this method are within two percent of official population estimates. Participants were restricted to those who were alive as at 31 December 2018, and to those that had spent no more than six consecutive months outside of New Zealand between 1 January 2017 and 31 December 2018. Time outside of New Zealand was determined using customs data. The later restriction was imposed to ensure each individual had spent the majority of their time in New Zealand, and hence had been exposed to the environment corresponding to their residential address.

2.4. Mental health

Mental health conditions were determined using an existing IDI-based case identification method developed by Bowden et al. (2020). This method draws from four health service use datasets: ICD-10-AM diagnosis codes from hospital admissions data (the National Minimum Dataset [NMDS]); ICD-10-AM and DSM-IV codes from specialty mental health service use data (the programme for the integration of mental health data [PRIMHD]); assigned diagnosis codes from needs assessment information (disability support services data [Socrates]); and inference from medication dispensing data (the pharmaceutical collection). The case identification method was developed to identify clinically relevant cases of mental health conditions, and to minimise the likelihood of false positives. It was not intended to estimate true prevalence. The systematic classification of codes to identify these mental health conditions was carried out by a group of eight specialists from various mental health related disciplines (e.g. clinical psychology, child and adolescent psychiatry, and child and adolescent mental health research). Any disagreements among the team regarding inference from pharmaceutical data was resolved by discussion and consensus. Details of the clinical coding used can be found in Bowden et al. (2020).

In the present study, the method was employed to identify mental health conditions across four key clinically relevant sub-groups: emotional disorders (anxiety and/or depression); behavioural disorders (attention deficit hyperactivity disorder, conduct disorders, oppositional defiant disorder); substance problems; and self-harm. An aggregate category of any mental health conditions was also created, including the aforementioned four sub-groups, in addition to psychotic disorders, bipolar disorder, sleep problems, personality disorder, eating disorders, other mental health, and mental health conditions not defined. Mental health conditions were identified over a one-year period, 1 January 2018 to 31 December 2018.

2.5. Environmental measures

Data on the location of health-constraining (i: fast-food outlets, ii: takeaway outlets, iii: dairy outlets and convenience stores, iv: alcohol outlets, and v: gaming venues), and health-promoting features (i: green spaces, ii: blue spaces, iii: physical activity facilities, iv: fruit and vegetable outlets, and v: supermarkets) were combined into a nationwide area-based Healthy Location Index (HLI). The HLI is available at the meshblock level (2018) for the whole of New Zealand (Fig. 1). Meshblock administrative units are the smallest geographic units for which statistical data are reported by Statistics New Zealand with an ideal size range of 30–60 dwellings (around 60–120 residents) (Statistics New Zealand, 2019). There were 52,923 meshblocks (oceanic meshblocks excluded) included in this analysis. The proximity from population weighted centroids of meshblock was calculated for each domain of health-promoting and health-constraining features and these were ranked (Marek et al., 2020, 2021a). These ranks were summed for health-promoting and health-constraining features, categorised by deciles, and then combined to provide the final HLI. A detailed description of the methodology together with the characteristics of the HLI are provided elsewhere (Marek et al., 2021a). The dataset is publicly available online (Marek et al., 2020).

For the present study, three levels of the HLI were used. Category 1 indicates health-promoting environments where access to health-promoting features outweigh the access to health-constraining features (zones 1–2, 1–3 and 1–3 in Fig. 1); 2 indicates health-constraining environments where access to health-constraining outweigh the access to health-promoting features (zones 2–1, 3–1 and 3–2); and 3 indicates environments that are neither health-promoting nor health-constraining (zones 1-1, 2-2 and 3-3).

2.6. Defining exposure

Exposure to environmental variables using the HLI (Marek et al., 2021a) was determined by linking IDI address notification data (change of residential address) over a two-year period (1 January 2017 to 31 December 2018) to the HLI by meshblock for each individual. The HLI category an individual resided in for the majority of time within the two-year period was chosen to assess exposure. A two-year long period of exposure was utilised due to possible lags in the association between exposure to an environment and the mental health of young people.

2.7. Socio-demographics

Sex (male/female), age (10–14, 15–19, 20–24 years), and ethnicity (derived using the total concept approach, meaning an individual can identify with multiple ethnic groups, and major ethnic groups using New Zealand Standard Classification, 2005V2.0.0: European/other; Māori; Pasifika; Asian; and Middle Eastern, Latin American, African [MELAA]) were extracted from the personal details table in the IDI. Area-level deprivation defined using the New Zealand Deprivation Index 2018 (NZDep 2018) (Atkinson et al., 2019), and the urban/rural profile of residence (Statistics New Zealand, 2020) utilised residence data from the IDI address notification table. NZDep2018 is an area-based socio--economic measure of deprivation based on the meshblock an individual lives in. Each meshblock is assigned a deprivation score that is then collapsed into quintiles, 1 (least deprived) and 5 (most deprived). The urban/rural profile of residence was defined by the Urban Rural Indicator 2018 which is based on residents, population density, and coverage of built physical structures for example (Statistics New Zealand, 2019, 2020). This metric was collapsed into a 5-level categorical variable: major urban areas (populations of 100,000 or more); large urban areas (30,000–99,999); medium urban areas (10,000–29,999); small urban areas (1000–9999) and rural areas (<1000). Time varying measures (age, NZDep 2018, and urban/rural) were determined as at 31 December 2018.

2.8. Statistical analyses

The June 2020 refresh of the IDI was used to access data, which were in turn extracted using SAS 7.1 (SAS Institute Inc, 2014). Stata MP version 15 (StataCorp. Stata Statistical Software, 2017) was used to analyse the data. All Statistics New Zealand confidentiality requirements were adhered to including random rounding to base three of all counts

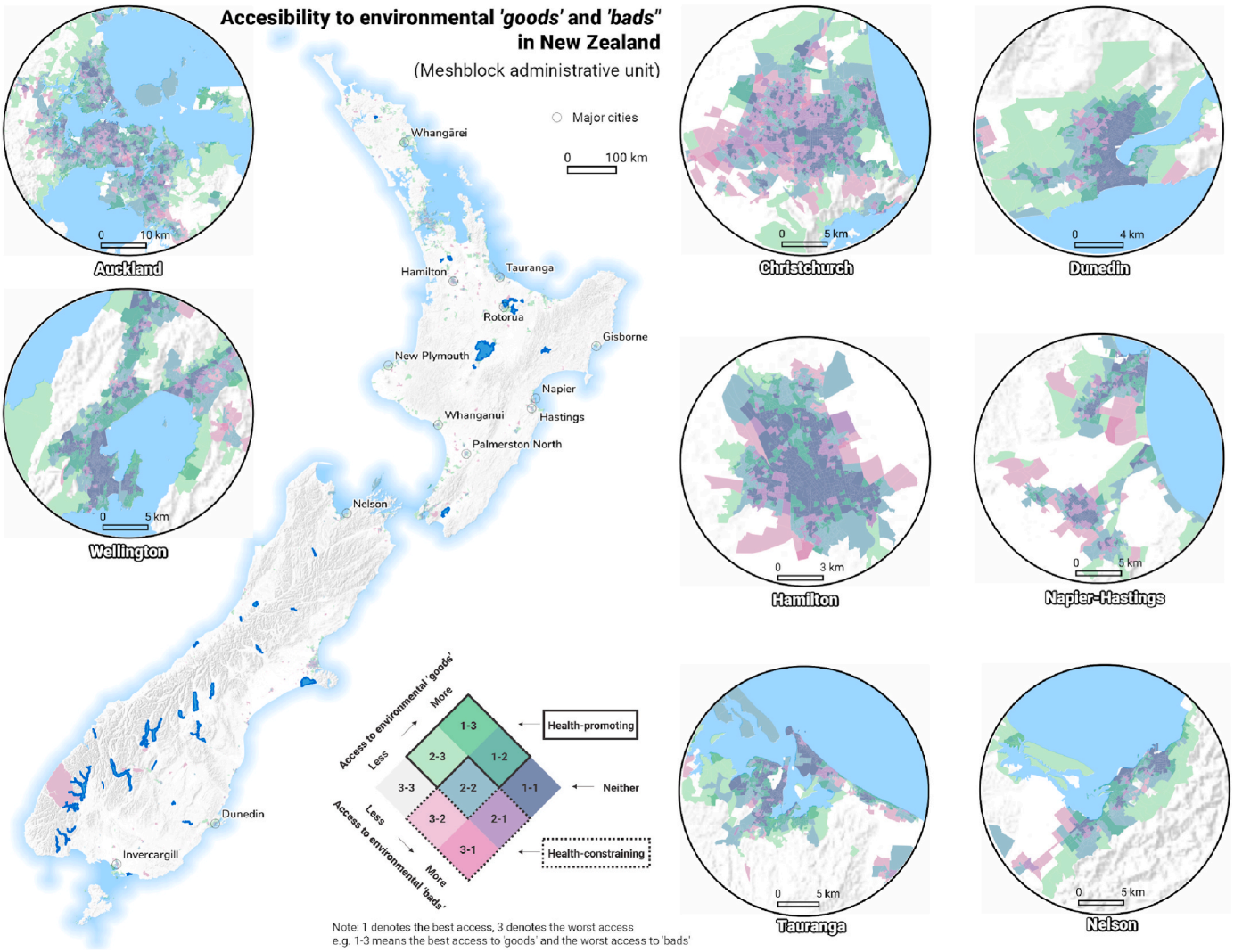

Fig. 1. The spatial distribution of accessibility to health-promoting and health-constraining features within the HLI for New Zealand and major cities.

and suppression of data for counts less than six. The Reporting of Studies Conducted using Observational Routinely-collected health Data (RECORD) guidelines were followed (Benchimol et al., 2015). The participant population and observed rates of identified mental health conditions were described in detail. Unadjusted odds ratios (OR), adjusted odds ratios (AOR), and associated 95% confidence intervals were generated for each mental health condition on socio-demographic sub-groups and HLI status using complete-case two-level random intercept logit model with individuals nested within District Health Boards (geographic health administration catchments in New Zealand). The adjusted models included all socio-demographic measures (sex, age, ethnicity, NZDep 2018, and urban/rural profile) as well as HLI status. Two separate sensitivity analyses were also conducted to model increasing duration of exposure to environments, restricting the analysis to individuals who spent at least 50% (sensitivity analysis 1: high exposure) and 80% (sensitivity analysis 2: very high exposure) of the two-year exposure period living in a particular HLI category. Two-tailed tests at the 5% level defined significance.

3. Results

3.1. Descriptive statistics

Table 1 shows socio-demographic characteristics of the 10–24 year old New Zealand ERP for 2018. Overall, among the 917,211 young people there was a relatively even split between sexes and age groups. The majority of the study cohort were European/other (68.8%) and 25.4% were Māori. Nearly a quarter of young people lived in the most deprived quintile (24.5%) and just over a half lived in major urban areas (53.6%). Approximately one in five young people spent the majority of the two-year exposure period (1 January 2017 to 31 December 2018) residing in health-promoting and health-constraining areas, respectively.

Overall, approximately one in ten (9.2%) young people were identified with any mental health condition during the 2018 calendar year. Among the mental health groups examined, emotional conditions were the most common (5.6%), followed by substance problems (1.4%), behavioural conditions (1.4%) and self-harm (0.4%).

Table 2 shows the identified prevalence of mental health conditions by HLI category of health-promoting, neither and health-constraining. Crude mental health identification rates show that any mental health and any emotional conditions were higher among those residing in health-constraining areas (9.7% and 5.9% respectively) compared to health-promoting areas (8.8% and 5.2% respectively). Substance problems were notably higher among those residing in health-constraining compared to health-promoting areas (1.5% vs. 1.2%). In contrast, observed rates of self-harm and behavioural problems were relatively stable across health-constraining and health-promoting environments.

Table 1
Socio-demographic characteristics of the 917,211 young people from the estimated resident population (2018).

	n	%
Sex		
Female	444,309	48.4
Male	472,902	51.6
Age (years)		
10-14	307,083	33.5
15-19	298,077	32.5
20-24	312,054	34.0
Ethnicity[a,c]		
European/other	630,603	68.8
Māori	232,623	25.4
Pasifika	118,650	12.9
Asian	141,984	15.5
MELAA[b]	15,342	1.7
Deprivation[d]		
1 (least deprived)	168,438	18.4
2	165,429	18.0
3	170,472	18.6
4	183,093	20.0
5 (most deprived)	225,006	24.5
Residential location[e]		
Major Urban	491,385	53.6
Large Urban	129,465	14.1
Medium Urban	70,488	7.7
Small Urban	82,821	9.0
Rural	138,459	15.1
Healthy Location Index[f]		
Health-promoting	187,257	20.4
Neither	538,440	58.7
Health-constraining	190,146	20.7

[a] Derived using the total concept approach meaning an individual can identify with multiple ethnic groups and totals add to >100%.
[b] Middle Eastern; Latin American; African.
[c] Values missing for 1962 young people (0.2%).
[d] Values missing for 4773 young people (0.5%).
[e] Values missing for 4593 young people (0.5%).
[f] Values missing for 1368 young people (0.1%).

Table 2
One-year prevalence of mental health condition identifications and associated population rates among the 917,211 young people from the estimated resident population (2018).

	Health-promoting		Neither		Health-constraining	
	n	%	n	%	n	%
Any mental health	16,566	8.8	49.635	9.2	18,435	9.7
Any emotional	9696	5.2	30,306	5.6	11,307	5.9
Any behavioural	2,8320	1.5	7326	1.4	2814	1.5
Substance problems	2316	1.2	7545	1.4	2805	1.5
Self-harm	678	0.4	2193	0.4	825	0.4

Table S1 (supplementary online materials) shows the prevalence of mental health conditions by socio-demographic characteristics.

Table 3 presents both the crude and adjusted odds ratios of mental health conditions for health-promoting and health-constraining environments, relative to environments that were neither. Effect sizes were often small, but findings indicate that the environment where a young person resided was associated with rates of mental health conditions in the hypothesised direction for all conditions except for any behavioural problems. Full regression models including covariate adjustment values are shown in Table S2 (online supplementary materials).

As shown in Table 3, young people residing in health-constraining environments had a significantly higher adjusted odds of any mental health condition. Similarly, residing in health-constraining environments was found to be significantly associated with increased odds of any emotional condition. Moreover, in crude analysis, residing in health-promoting environments was associated with a significant reduction in odds of emotional problems, however, following adjustment this association was fully attenuated. Significantly lower crude and adjusted odds of substance problems were found for those residing in health-promoting environments. For self-harm, unadjusted analysis indicated a significant reduction in odds for those residing in health constraining environments, however, after adjustment, despite an effect size indicating a similar association, this finding no longer remained significant. For behavioural conditions, after adjustment, no significant associations were found with the type of environment a young person resided within.

Results from two separate sensitivity analyses to model increasing levels of exposure to environments during the two-year exposure period (high exposure defined as >50% of last two years in one HLI category and very high exposure defined as >80% of last two years in one HLI category) are presented in Tables S3 and S4 respectively (online supplementary materials). With the exception of behavioural conditions, the effect of living in health-promoting environments on reduced odds of mental health conditions was strengthened with increased exposure. Moreover, at the highest level of exposure, the association between living in a health-promoting environment and any mental health condition and self-harm both became significant after adjustment for covariates. In contrast, greater exposure to health-constraining environments tended to weaken the effect of increased odds of mental health conditions. For example, the higher odds of emotional conditions were attenuated but remained statistically significant with increased exposure, while, for any mental health condition the previous finding of a statistically significant reduction in odds was fully attenuated.

4. Discussion

This study utilised powerful and rigorous population-level data from almost one million New Zealand young people to explore the relationship between exposure to a comprehensive range of environmental features and the prevalence of four significant mental health conditions,

Table 3
Unadjusted and adjusted[a] odds ratios for mental health conditions by HLI from two-level mixed effects logistic regression with random intercepts by District Health Board.

	Any mental health		Any emotional		Any behavioural		Substance problems		Self-harm	
	OR [95% CI]	AOR [95% CI]	OR [95% CI]	AOR [95% CI]	OR [95% CI]	AOR [95% CI]	OR [95% CI]	AOR [95% CI]	OR [95% CI]	AOR [95% CI]
Healthy Location Index										
Health-promoting	0.991 [0.973, 1.010]	0.993 [0.974, 1.012]	**0.975 [0.952, 0.999]**	0.991 [0.967, 1.016]	**1.116 [1.067, 1.167]**	1.020 [0.974, 1.067]	**0.896 [0.854, 0.940]**	**0.950 [0.905, 0.997]**	**0.912 [0.836, 0.995]**	0.926 [0.848, 1.012]
Neither	1 [reference]		1 [reference]		1 [reference]		1 [reference]		1 [reference]	
Health-constraining	**1.026 [1.007, 1.045]**	**1.020 [1.001, 1.040]**	1.016 [0.993, 1.040]	**1.037 [1.012, 1.062]**	**1.063 [1.017, 1.112]**	1.016 [0.970, 1.064]	1.035 [0.990, 1.083]	0.968 [0.925, 1.014]	1.062 [0.978, 1.152]	1.030 [0.949, 1.119]

[a] Adjusted for sex, age, ethnicity, area-level deprivation, and urban/rural classification.

namely emotional, behavioural, substance problems and self-harm. We found that young people residing in more health-constraining environments had higher odds of developing any mental health condition, especially emotional problems. Conversely, young people residing in more health-promoting environments had lower odds of developing substance problems. Effects were small, but significant. There was no obvious association between the type of environment and behavioural problems.

Our findings broadly support previous international evidence that has demonstrated that the environments in which people live and their characteristics are associated with mental health conditions (Green et al., 2018; Hobbs et al., 2021c). Worth mentioning is an openly available Access to Healthy Assets and Hazards metric for Great Britain, which demonstrated that living in areas with poorer environmental quality was associated with poorer mental wellbeing (Green et al., 2018). Health-constraining features such as gaming venues and alcohol outlets are related to broader social harm including crime (Day et al., 2012) and increased rates of hazardous drinking in adults (Hobbs et al., 2020). However, our study combined data on the location of five health-constraining (e.g. fast-food outlets, alcohol outlets) and five health-promoting features (e.g. green spaces, fruit and vegetable outlets). It reinforces previous research (Macdonald et al., 2018; Green et al., 2018; Hobbs et al., 2021c) that highlights how accounting for the multiple characteristics of the environment are important and are associated with mental health conditions. Indeed, a recent study using nationally representative pooled New Zealand Health Survey data demonstrated that residing within health-constraining environments was associated with poorer mental health and higher levels of psychological distress among adults (Hobbs et al., 2021c). Effects in our study are smaller than those of the New Zealand Health Survey study (Hobbs et al., 2021c) however, the previous study was carried out in a pooled nationally representative sample of adults, and the relationship that adults have with the environment or impact of the environment on adults may be different to young people (Cherrie et al., 2018). Further, the data in the current study are derived from service use rather than self-reported measures of psychological distress.

Our study not only investigates the association with a range of mental health conditions, combined into a category called 'any mental health condition' but also explores associations with key sub-groups, which include emotional conditions, behavioural conditions, substance problems and self-harm. In this study, increased odds of any mental health or emotional condition were associated with residing in health-constraining environments. This supports a range of previous research, which has related the environment to emotional mental health conditions (Roberts et al., 2019; Hobbs et al., 2021c; Eze et al., 2020; Braithwaite et al., 2019; Pearce et al., 2018; Soga et al., 2017). Our findings also reflect wider evidence such that residing within health-promoting environments relates to reduced risk of substance abuse (Helbich et al., 2018; White et al., 2021; Jiang et al., 2021; Min et al., 2017). In contrast, after adjustment we found no significant associations between the environment and behavioural conditions. While we demonstrate associations between the environment a young person grows up in and some mental health conditions but not others, we are unable to explain *why* these associations may be occurring or not. Future research will need to explore what is driving the association for instance, between emotional conditions but not behavioural conditions. Importantly, there may be other influences on a young person's mental health that are not captured in this study such as social, cultural and economic circumstances. Related to this, we explore findings focusing only on service use for Māori and Pasifika in two recently published articles which detail findings for Māori (Theodore et al., 2022) and Pasifika (Ruhe et al., 2022) exclusively. Our study on Māori service use shows that despite known high levels of mental health concerns for rangatahi Māori, administrative data suggests significant under-reporting, assessment, and treatment of emotional conditions relative to non-Māori/non-Pasifika (Theodore et al., 2022).

The residential address history data contained within the IDI allowed us to explore in sensitivity analyses the impact of the duration of exposure to an environment. Our sensitivity analyses reflected the importance of accounting for exposure duration but also highlighted another potential seldom considered limitation of geospatial research. Greater exposure in this study meant that the effect of living in health-promoting environments on reduced odds of mental health conditions tended to strengthen. However, somewhat counterintuitively, the effect of living in health-constraining environments on increased odds of mental health conditions were attenuated. A possible explanation for these patterns is that by restricting the analysis to those who spent increasing time residing in a single HLI category, we excluded individuals with high levels of residential mobility. By definition, those who remain in the analytical sample with greater duration to the same environment for the sensitivity analyses, are disproportionately less likely to be transient and transience has been shown to be associated with increased incidence of mental health conditions and other adverse social harms (Marek et al., 2021b, 2023). For this reason, the sensitivity analyses may capture both an exposure effect, as well as the effect of restricting the analysis to those who are less transient. Better accounting for historical residential address history is an important area for further investigation. Previous studies have made calls for more longitudinal research; however, such investigations are rarely made within the literature (Marek et al., 2023; Hobbs and Atlas, 2019). Future studies should provide a more comprehensive examination of how changes in exposure to environments are related to subsequent mental health conditions, including accounting for transience, to begin to better establish causal associations (Desjardins et al., 2023). Accounting for exposure over time and aspects of population transience may allow research to better detect more realistic associations between specific exposures and outcomes of interest in a field that is dominated by cross-sectional research designs (Bowler et al., 2010; Hajat et al., 2015; Britton et al., 2018; Wilkins et al., 2019). Moreover, it may be that the environment matters more for some populations than others, for specific mental health conditions more than others, or that some of the specific elements that are combined in the HLI are responsible for the associations with mental health conditions. These concepts should be explored in future evidence in both adult and child populations (Marek et al., 2021a).

Mental health is multifaceted in aetiology and environmental determinants have been increasingly recognised as contributors to their prevalence in recent years (Dopp and Lantz, 2020; Böbel et al., 2018; Britton et al., 2018). Addressing the environmental determinants of health has received increasing attention from international bodies such as the World Health Organization (World Health Organisation, 2017, 2019, 2020), United Nations (United Nations, 2020), and national and regional bodies within New Zealand. The findings in this study use a large population-level dataset of approximately one million young people relating to the environmental determinants of mental health and provide some considerations for national policy. Our investigation supports to some extent the increasing interest from policymakers in restricting the proliferation of adverse environmental features while advocating for health-promoting features through planning restrictions or wider policy initiatives (Dopp and Lantz, 2020; Cavill and Rutter, 2013a; Cavill and Rutter, 2013b; Town and Country Planning Association (TCPA), 2020; Town and Country Planning Association, 2016; Town and Country Planning Association, 2014; Rajput et al., 2019). For instance, the UN sustainable health goal is *"by 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities"* (Sustainable Development Solutions Network, 2012). While effects were small, our study adds to current logic by suggesting policymakers should consider the broader environment and account for how features co-occur rather than targeting features in isolation. Indeed, previous international and New Zealand research has documented that environmental features often cluster together (Macdonald et al., 2018; Green

et al., 2018; Marek et al., 2021a). For instance, alcohol outlets may collocate in areas where gaming venues or indeed even more health-promoting venues such as physical activity facilities may also locate due to customer demand, land-use patterns or planning regulations (Macdonald et al., 2018). In the New Zealand context, the findings of this study provide some evidence that support a number of recommendations from *He Ara Oranga: Report of the Government Inquiry* into Mental Health and Addiction (Patterson et al., 2018). Overall, policymakers could use the HLI (Marek et al., 2020, 2021a) and evidence from this paper and others (Green et al., 2018; Hobbs et al., 2021c) to help justify a focus on the environmental determinants of mental health, which includes access to and the quality of our neighbourhoods to create a more holistic vision of what a healthy place or neighbourhood could be rather than focusing environmental features in isolation.

This study seeks to advance existing knowledge by using a novel nationwide area-based measure called the Healthy Location Index (HLI) (Marek et al., 2021a). The HLI expresses multivariate exposure to a comprehensive range of health-promoting and health-constraining environments. It measures accessibility using the most contemporary data available which was up-to-date in 2018. Importantly, this provides a temporal match to mental health data. In addition, we also use meshblocks which are the smallest possible administrative units ensuring further confidence in study findings. Despite this, we potentially introduce the ecological fallacy due to using a combination of both individual-level and area-based (aggregated) data where assumptions are made that individuals are exposed to the environment that is described on aggregate level, for instance in the HLI and NZDep 2018. Moreover, the Healthy Location Index is a proximity based measure and does not account for density or actual use of environmental features. Having said this, availability and proximity have recently shown to be highly correlated (Hobbs et al., 2017b; Burgoine et al., 2013).

We utilise temporal address change data linked to novel geospatial data to ascertain the environments individuals have resided over time and we were also able to account for individuals who spent large portions of the study period overseas and/or died during the study period using linked customs and mortality data respectively improving the confidence in our geospatial exposure. It is also important to note that this study investigates associations between the environment and mental health as opposed to causality. We also do not conceptualise the space in the analysis and assume that effects are the same/comparable throughout New Zealand even though it is highly likely that associations are changeable in space (e.g. regionally). Future research could investigate this further by exploring spatial autocorrelation or using spatial econometrics models such as spatial-lag regression to explore more local effects. In addition, our previous work which developed the HLI demonstrated some degree of correlation between accessibility to ranked health-promoting environmental features and environmental health-constraining features. For instance, often but not always, in the more deprived areas there was good access to health-constraining features but limited access to health-promoting environmental features.

Future research should also explore the use of such environmental features to better account for actual exposure and usage of environmental features such as gaming venues or alcohol outlets (Liu et al., 2020). Our study did not account for potential confounding of residential self-selection bias, such that individuals may choose their residential location based on attributes that allow them to stay healthy (e.g., greenspace) (Cao et al., 2009). Finally, while we did not find any significant associations between health-promoting environments and mental health problems, future research could explore more positive outcomes of mental health such as resilience which may be more strongly linked to health-promoting environments (Alderton et al., 2019; Bratman et al., 2019).

For the individual-level data, we have used the IDI to construct a nationwide cohort of young people and utilised novel linked health service use data to identify a range of mental health conditions. Despite this, the case identification method for mental health remains unvalidated. As such, the extent to which this method incorrectly identifies conditions is unknown. In addition, due to the method being based on health service use data, we know that it may undercount mental health prevalence. Moreover, the method identifies some mental health concerns through inference made from medication dispensing which may be at further risk of misspecification. Future research could make use of the population-level nature of these data and examine the relationship between mental health and the environment among population sub-groups. More specifically, future research using large samples like this study in the IDI could also seek to explore any effect modification or interaction in the association between the environment and mental health by gender or age for instance.

5. Conclusion

We provide evidence of small yet significant associations between increased exposure to health-promoting environmental features and reduced exposure to health-constraining environmental features and improved mental health for young people in New Zealand. The findings provide some support to the hypothesis that the environment a child grows up in, especially the combined influence of multiple environmental facets, may contribute to their mental health condition. Consequently, leverage points for decreasing mental health prevalence can be sought in upstream environmental based interventions.

Funding

- This research was funded by A Better Start/Cure Kids 2021 research grant [Reference: Bowden 2021MRP-006]. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.
- Prof Boden funded by the Health Research Council of New Zealand (Programme Grant 16/600).
- Mr Bowden, Dr Kokaua, Assoc Prof Hetrick and Assoc Prof Milne are funded by the Ministry of Business, Innovation and Employment, through the A Better Start National Science Challenge (Grant Number: UOAX1511).
- Assoc Prof Reremoana Theodore is funded by the Health Research Council of New Zealand Māori Health Emerging Leader Fellowship [18/644].
- Dr Lukas Marek and Dr Jesse Wiki work within the GeoHealth Laboratory which is funded by the New Zealand Ministry of Health.
- Assoc Prof Hetrick is the Principal Clinical Advisor for the Suicide Prevention Office, Ministry of Health
- Dr Kokaua and Dr Ruhe are funded by the Health Research Council of New Zealand (Programme Grant 20/115 and 20/116).

Author contributions

M Hobbs: conception of idea, data curation, investigation, study design, project administration, resources, software, supervision, validation, visualisation, writing - original draft and writing - review and editing.N Bowden: conception of idea, data curation, investigation, study design, project administration, resources, software, supervision, validation, visualisation, writing - original draft and writing - review and editing.L Marek: conception of idea, data curation, visualisation, writing - original draft and writing - review and editing.J Kokaua: study design, writing - original draft and writing - review and editing.R Theodore: study design, writing - original draft and writing - review and editing.J Wiki: conception of idea, data curation, visualisation, writing - original draft and writing - review and editing.T Ruhe: study design, writing - original draft and writing - review and editing.J Boden: study design, writing - original draft and writing - review and editing.H Thabrew: interpretation of data, writing - original draft and writing - review and editing.S Hetrick: conception of idea, writing - original draft and writing - review and editing.B Milne: study design, writing - original draft and

writing - review and editing.

Disclaimer

These results are not official statistics. They have been created for research purposes from the Integrated Data Infra-structure (IDI) which is carefully managed by Stats NZ. For more information about the IDI please visit https://www.stats.govt.nz/integrated-data/.

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.

Data availability

The authors do not have permission to share data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2023.115893.

References

Alderton, A., Villanueva, K., O'Connor, M., Boulangé, C., Badland, H., 2019. Reducing inequities in early childhood mental health: how might the neighborhood built environment help close the gap? A systematic search and critical review. Int. J. Environ. Res. Publ. Health 16 (9).

Atkinson, J., Salmond, C., Crampton, P., 2019. NZDep2018 Index of Deprivation: Interim Research Report, December 2019. Wellington, New Zealand.

Benchimol, E.I., Smeeth, L., Guttmann, A., Harron, K., Moher, D., Petersen, I., et al., 2015. The REporting of studies conducted using observational routinely-collected health data (RECORD) statement. PLoS Med. 12 (10), e1001885.

Black, C., Moon, G., Baird, J., 2014. Dietary inequalities: what is the evidence for the effect of the neighbourhood food environment? Health Place 13, 131.

Böbel, T.S., Hackl, S.B., Langgartner, D., Jarczok, M.N., Rohleder, N., Rook, G.A., et al., 2018. Less immune activation following social stress in rural vs. urban participants raised with regular or no animal contact, respectively. Proc. Natl. Acad. Sci. USA 115 (20), 5259–5264.

Bowden, N., Gibb, S., Thabrew, H., Kokaua, J., Audas, R., Merry, S., et al., 2020. Case identification of mental health and related problems in children and young people using the New Zealand Integrated Data Infrastructure. BMC Med. Inf. Decis. Making 20 (1), 42.

Bowler, D.E., Buyung-Ali, L.M., Knight, T.M., Pullin, A.S., 2010. A systematic review of evidence for the added benefits to health of exposure to natural environments. BMC Publ. Health 10 (1), 456.

Braithwaite, I., Zhang, S., Kirkbride James, B., Osborn David, P.J., Hayes Joseph, F., 2019. Air pollution (particulate matter) exposure and associations with depression, anxiety, bipolar, psychosis and suicide risk: a systematic review and meta-analysis. Environ. Health Perspect. 127 (12), 126002.

Bratman, G.N., Anderson, C.B., Berman, M.G., Cochran, B., de Vries, S., Flanders, J., et al., 2019. Nature and mental health: an ecosystem service perspective. Sci. Adv. 5 (7), eaax0903.

Britton, E., Kindermann, G., Domegan, C., Carlin, C., 2018. Blue care: a systematic review of blue space interventions for health and wellbeing. Health Promot. Int. 35 (1), 50–69.

Britton, E., Kindermann, G., Domegan, C., Carlin, C., 2020. Blue care: a systematic review of blue space interventions for health and wellbeing. Health Promot. Int. 35 (1), 50–69.

Burgoine, T., Alvanides, S., Lake, A.A., 2013. Creating obesogenic realities do our methodological choices make a difference when measuring the food environment. Int. J. Health Geogr. 12, 33.

Campbell, M., Marek, L., Hobbs, M., 2021. Reconsidering Movement and Exposure: towards a More Dynamic Health Geography. Geography Compass.

Cao, X., Mokhtarian, P., Handy, S., 2009. Examining the impacts of residential self-selection on travel behaviour: a focus on empirical findings. Transport Rev. 29 (3), 359–395.

Cavill, N., Rutter, H., 2013a. Healthy People, Healthy Places Briefing: Obesity and the Environment: Increasing Physical Activity and Active Travel. Public Health England, London.

Cavill, N., Rutter, H., 2013b. Healthy People, Healthy Places Briefing: Obesity and the Environment: Regulating the Growth of Fast Food Outlets. Public Health England, London.

Cherrie, M.P.C., Shortt, N.K., Mitchell, R.J., Taylor, A.M., Redmond, P., Thompson, C.W., et al., 2018. Green space and cognitive ageing: a retrospective life course analysis in the Lothian Birth Cohort 1936. Soc. Sci. Med. 196 (Suppl. C), 56.

Colman, I., Murray, J., Abbott, R.A., Maughan, B., Kuh, D., Croudace, T.J., et al., 2009. Outcomes of conduct problems in adolescence: 40 year follow-up of national cohort. BMJ 338, a2981.

Copeland, W.E., Wolke, D., Shanahan, L., Costello, E.J., 2015. Adult functional outcomes of common childhood psychiatric problems: a prospective, longitudinal study. JAMA Psychiatr. 72 (9), 892–899.

Dadvand, P., Nieuwenhuijsen, M.J., Esnaola, M., Forns, J., Basagaña, X., Alvarez-Pedrerol, M., et al., 2015. Green spaces and cognitive development in primary schoolchildren. Proc. Natl. Acad. Sci. USA 112 (26), 7937–7942.

Day, P., Breetzke, G., Kingham, S., Campbell, M., 2012. Close proximity to alcohol outlets is associated with increased serious violent crime in New Zealand. Aust. N. Z. J. Publ. Health 36 (1), 48–54.

Desjardins, M.R., Murray, E.T., Baranyi, G., Hobbs, M., Curtis, S., 2023. Improving longitudinal research in geospatial health: an agenda. Health Place 80, 102994.

Dopp, A.R., Lantz, P.M., 2020. Moving upstream to improve children's mental health through community and policy change. Adm. Pol. Ment. Health 47 (5), 779–787.

Engemann, K., Pedersen, C.B., Arge, L., Tsirogiannis, C., Mortensen, P.B., Svenning, J.-C., 2019. Residential green space in childhood is associated with lower risk of psychiatric disorders from adolescence into adulthood. Proc. Natl. Acad. Sci. USA 116 (11), 5188.

Eze, I.C., Foraster, M., Schaffner, E., Vienneau, D., Pieren, R., Imboden, M., et al., 2020. Incidence of depression in relation to transportation noise exposure and noise annoyance in the SAPALDIA study. Environ. Int. 144, 106014.

Feng, J., 2010. The built environment and obesity: a systematic review of the epidemiologic evidence. Health Place 16.

Fergusson, D.M., Horwood, J.L., 2001. The christchurch health and development study: review of findings on child and adolescent mental health. Aust. N. Z. J. Psychiatr. 35 (3), 287–296.

Fergusson, D.M., Horwood, L.J., Lynskey, M.T., 1993. The effects of conduct disorder and attention deficit in middle childhood on offending and scholastic ability at age 13. J. Child Psychol. Psychiatry Allied Discip. 34 (6), 899–916.

Fergusson, D.M., Horwood, L.J., Ridder, E.M., 2005. Show me the child at seven: the consequences of conduct problems in childhood for psychosocial functioning in adulthood. J. Child Psychol. Psychiatry Allied Discip. 46 (8), 837–849.

Gibb, S., Bycroft, C., Matheson-Dunning, N., 2016. Identifying the New Zealand Resident Population in the Integrated Data Infrastructure (IDI). Statistics New Zealand, Wellington.

Green, M.A., Daras, K., Davies, A., Barr, B., Singleton, A., 2018. Developing an Openly Accessible Multi-Dimensional Small Area Index of 'Access to Healthy Assets and Hazards' for Great Britain, 2016, vol. 54. Health & place, pp. 11–19.

Hajat, A., Hsia, C., O'Neill, M.S., 2015. Socioeconomic disparities and air pollution exposure: a global review. Curr Environ Health Rep 2 (4), 440–450.

Hartig, T., Kaiser, F.G., Strumse, E., 2007. Psychological restoration in nature as a source of motivation for ecological behaviour. Environ. Conserv. 34 (4), 291–299.

Heidinger, L.S., Willson, A.E., 2019. The childhood roots of adult psychological distress: interdisciplinary perspectives toward a better understanding of exposure to cumulative childhood adversity. Child Abuse Negl. 97, 104136.

Helbich, M., 2018. Mental health and environmental exposures: an editorial. Int. J. Environ. Res. Publ. Health 15 (10), 2207.

Helbich, M., de Beurs, D., Kwan, M.-P., O'Connor, R.C., Groenewegen, P.P., 2018. Natural environments and suicide mortality in The Netherlands: a cross-sectional, ecological study. Lancet Planet. Health 2 (3), e134–e139.

Hobbs, M., Atlas, J., 2019. Environmental influences on behaviour and health: a call for creativity and radical shifts in thinking within contemporary research. N. Z.Med. J. 132 (1505), 97–99.

Hobbs, M., Griffiths, C., , M G, Jordan, H., Saunders, J., McKenna, J., 2017a. Neighbourhood Typologies and Associations with Body Mass Index and Obesity: a Cross-Sectional Study Preventive Medicine.

Hobbs, M., Green, M., Griffiths, C., Jordan, H., Saunders, J., McKenna, J., 2017b. How different data sources and definitions of neighbourhood influence the association between food outlet availability and body mass index: a cross-sectional study. Perspect Public Health 137 (3), 158–161.

Hobbs, M., Green, M.A., Wilkins, E., Lamb, K.E., McKenna, J., Griffiths, C., 2019. Associations between food environment typologies and body mass index: evidence from Yorkshire, England. Soc. Sci. Med. 239, 112528.

Hobbs, M., Marek, L., Wiki, J., Campbell, M., Deng, B.Y., Sharpe, H., et al., 2020. Close proximity to alcohol outlets is associated with increased crime and hazardous drinking: pooled nationally representative data from New Zealand. Health Place 65, 102397.

Hobbs, M., Moltchanova, E., Wicks, C., Pringle, A., Griffiths, C., Radley, D., et al., 2021a. Investigating the environmental, behavioural, and sociodemographic determinants of attendance at a city-wide public health physical activity intervention: longitudinal evidence over one year from 185,245 visits. Prev. Med. 143, 106334.

Hobbs, M., Mackenbach, J.D., Wiki, J., Marek, L., McLeod, G.F.H., Boden, J.M., 2021b. Investigating change in the food environment over 10 years in urban New Zealand: a longitudinal and nationwide geospatial study. Soc. Sci. Med. (269), 113522

Hobbs, M., Kingham, S., Wiki, J., Marek, L., Campbell, M., 2021c. Unhealthy environments are associated with adverse mental health and psychological distress: cross-sectional evidence from nationally representative data in New Zealand. Prev. Med., 106416

Jiang, W., Stickley, A., Ueda, M., 2021. Green space and suicide mortality in Japan: an ecological study. Soc. Sci. Med. 282, 114137.

Kjelsberg, E., 2002. DSM-IV conduct disorder symptoms in adolescents as markers of registered criminality. Eur. Child Adolesc. Psychiatr. 11 (1), 2–9.

Kvalsvig, A., Gibb, S., Teng, A., 2019. Linkage Error and Linkage Bias: a Guide for IDI Users. University of Otago, Wellington.

Lakerveld, J., Mackenbach, J., 2017. The upstream determinants of adult obesity. Obes. Facts 10 (3), 216.
Layton, T.J., Barnett, M.L., Hicks, T.R., Jena, A.B., 2018. Attention deficit–hyperactivity disorder and month of school enrollment. N. Engl. J. Med. 379 (22), 2122–2130.
Leventhal, T., Brooks-Gunn, J., 2003. Moving to opportunity: an experimental study of neighborhood effects on mental health. Am. J. Publ. Health 93 (9), 1576–1582.
Liu, B., Widener, M., Burgoine, T., Hammond, D., 2020. Association between time-weighted activity space-based exposures to fast food outlets and fast food consumption among young adults in urban Canada. Int. J. Behav. Nutr. Phys. Activ. 17 (1), 62.
Macdonald, L., Olsen, J.R., Shortt, N.K., Ellaway, A., 2018. Do 'environmental bads' such as alcohol, fast food, tobacco, and gambling outlets cluster and co-locate in more deprived areas in Glasgow City, Scotland? Health Place 51, 224–231.
Macintyre, S., Macdonald, L., Ellaway, A., 2008. Do poorer people have poorer access to local resources and facilities? The distribution of local resources by area deprivation in Glasgow, Scotland. Soc. Sci. Med. 67 (6), 900–914.
Mackenbach, J., Rutter, H., Compernolle, S., Glonti, K., Oppert, J.-M., Charreire, H., et al., 2014. Obesogenic environments: a systematic review of the association between the physical environment and adult weight status, the SPOTLIGHT project. BMC Publ. Health 14 (1), 233.
Maguire, E.R., Burgoine, T., Monsivais, P., 1990-2008. Area deprivation and the food environment over time: a repeated cross-sectional study on takeaway outlet density and supermarket presence in Norfolk, UK. Health Place 2015 (33), 142.
Manisalidis, I., Stavropoulou, E., Stavropoulos, A., Bezirtzoglou, E., 2020. Environmental and health impacts of air pollution: a review. Front. Public Health 8, 14.
Marek, L., Campbell, M., Epton, M., Kingham, S., Storer, M., 2018. Winter is coming: a socio-environmental monitoring and spatiotemporal modelling approach for better understanding a respiratory disease. ISPRS Int. J. Geo-Inf. 7 (11).
Marek, L., Hobbs, M., Wiki, J., Kingham, S., Campbell, M., 2020. The Healthy Living Index (HLI) for New Zealand Christchurch. GeoHealth Laboratory. Available from: https://www.canterbury.ac.nz/science/research/geohealth/publications-reports-and-data/.
Marek, L., Hobbs, M., Wiki, J., Kingham, S., Campbell, M., 2021a. The good, the bad, and the environment: developing an area-based measure of access to health-promoting and health-constraining environments in New Zealand. Int. J. Health Geogr. 20 (1), 16.
Marek, L., Greenwell, J., Hobbs, M., McCarthy, J., Wiki, J., Campbell, M., et al., 2021b. Combining large linked social service microdata and geospatial data to identify vulnerable populations in New Zealand. In: Birkin, M., Clarke, G., Corcoran, J., Stimson, R. (Eds.), Big Data Applications in Geography and Planning. Edward Elgar Publishing, pp. 52–63.
Marek, L., Hills, S., Wiki, J., Campbell, M., Hobbs, M., 2023. Towards a better understanding of residential mobility and the environments in which adults reside: a nationwide geospatial study from Aotearoa New Zealand. Habitat Int. 133, 102762.
Markevych, I., Schoierer, J., Hartig, T., Chudnovsky, A., Hystad, P., Dzhambov, A.M., et al., 2017. Exploring pathways linking greenspace to health: theoretical and methodological guidance. Environ. Res. 158, 301–317.
Mason, K.E., Palla, L., Pearce, N., Phelan, J., Cummins, S., 2020. Genetic risk of obesity as a modifier of associations between neighbourhood environment and body mass index: an observational study of 335 046 UK Biobank participants. BMJ Nutr Prev Health bmjnph-2020-000107. https://pubmed.ncbi.nlm.nih.gov/33521535/. bmjnph-2020-000107.
Milne, B.J., Atkinson, J., Blakely, T., Day, H., Douwes, J., Gibb, S., et al., 2019. Data resource profile: the New Zealand integrated data infrastructure (IDI). Int. J. Epidemiol. 48 (3), 677–e.
Min, K-b, Kim, H.-J., Kim, H.-J., Min, J-y, 2017. Parks and green areas and the risk for depression and suicidal indicators. Int. J. Publ. Health 62 (6), 647–656.
Moffitt, T.E., Caspi, A., Taylor, A., Kokaua, J., Milne, B.J., Polanczyk, G., et al., 2010. How common are common mental disorders? Evidence that lifetime prevalence rates are doubled by prospective versus retrospective ascertainment. Psychol. Med. 40 (6), 899–909.
Nobles, J., Summerbell, C., Brown, T., Jago, R., Moore, T., 2021. A secondary analysis of the childhood obesity prevention Cochrane Review through a wider determinants of health lens: implications for research funders, researchers, policymakers and practitioners. Int. J. Behav. Nutr. Phys. Activ. 18 (1), 22.
Patterson, R., Durie, M., Disley, B., Tiatia-Seath, J., Tualamali'i, J., 2018. He Ara Oranga: Report of the Government Inquiry into Mental Health and Addiction. Government Inquiry into Mental Health and Addiction, Wellington.
Pearce, J., Day, P., Witten, K., 2008. Neighbourhood provision of food and alcohol retailing and social deprivation in urban New Zealand. Urban Pol. Res. 26 (2), 213–227.
Pearce, J., Cherrie, M., Shortt, N., Deary, I., Ward Thompson, C., 2018. Life course of place: a longitudinal study of mental health and place. Trans. Inst. Br. Geogr. 43 (4), 555–572.
Pearson, A.L., Pearce, J., Kingham, S., 2013. Deprived yet healthy: neighbourhood-level resilience in New Zealand. Soc. Sci. Med. 91, 238–245.
Rajput, S., Aziz, M., Siddiqui, M., 2019. Social determinants of health and alcohol consumption in the UK. Epidemiology Biostatistics and Public Health 16 (3) e131128-1.
Roberts, S., Arseneault, L., Barratt, B., Beevers, S., Danese, A., Odgers, C.L., et al., 2019. Exploration of NO2 and PM2.5 air pollution and mental health problems using high-resolution data in London-based children from a UK longitudinal cohort study. Psychiatr. Res. 272, 8–17.
Rook, G.A., 2013. Regulation of the immune system by biodiversity from the natural environment: an ecosystem service essential to health. Proc. Natl. Acad. Sci. U. S. A 110 (46), 18360–18367.
Rose, G., 1985. Sick individuals and sick populations. Int. J. Epidemiol. 14.
Ruhe, T., Bowden, N., Theodore, R., Stanley-Wishart, B., Hetrick, S., Thabrew, H., et al., 2022. Identification of mental health and substance use-related conditions among Pasifika young people in Aotearoa New Zealand - a national cross-sectional study using the Integrated Data Infrastructure (IDI). The Journal of Pacific Research 21 (10).
Sadler, R.C., Hippensteel, C., Nelson, V., Greene-Moton, E., Furr-Holden, C.D., 2019. Community-engaged development of a GIS-based healthfulness index to shape health equity solutions. Soc. Sci. Med. 227, 63–75.
SAS Institute Inc, 2014. SAS 7.1. SAS Institute Inc.
Shim, R.S., Compton, M.T., 2018. Addressing the social determinants of mental health: if not now, when? If not us. Who? Psychiatric services (Washington, DC) 69 (8), 844–846.
Soga, M., Gaston, K.J., Yamaura, Y., 2017. Gardening is beneficial for health: a meta-analysis. Preventive Medicine Reports 5, 92–99.
StataCorp. Stata Statistical Software: Release vol. 15. College Station: StataCorp LLC; 2017.
Statistics New Zealand, 2017. How We Keep IDI and LBD Data Safe Wellington: Statistics New Zealand [Available from: http://archive.stats.govt.nz/browse_for_stats/snapshotsof-nz/integrateddatainfrastructure/keep-data-safe.aspx.
Statistics New Zealand, 2019. Statistical Standard for Geographic Areas 2018: New Standard Released Wellington: Statistics New Zealand [Available from: http://archive.stats.govt.nz/methods/classifications-and-standards/current-classifications-and-standards-review/review-geographic.aspx.
Statistics New Zealand, 2020. Urban Accessibility – Methodology and Classification Wellington: Statistics New Zealand [Available from: https://www.stats.govt.nz/assets/Uploads/Methods/Urban-accessibility-methodology-and-classification/Download-document/Urban-accessibility-methodology-and-classification.pdf.
Sushil, Z., Vandevijvere, S., Exeter, D.J., Swinburn, B., 2017. Food swamps by area socioeconomic deprivation in New Zealand: a national study. Int. J. Publ. Health 1–9.
Sustainable Development Solutions Network, 2012. Indicators and a Monitoring Framework: Launching a Data Revolution for the Sustainable Development Goals Paris: Sustainable Development Solutions Network. Available from: https://indicators.report/targets/11-7/.
Theodore, R., Bowden, N., Kokaua, J., Ruhe, T., Hobbs, M., Hetrick, S., et al., 2022. Mental health inequities for Māori youth: a population-level study of mental health service data. N. Z.Med. J. 135 (1567), 79–90.
Town and Country Planning Association, 2014. Planning Healthy Weight Environments - a TCPA Reuniting Health with Planning Project. Public Health England, London.
Town and Country Planning Association, 2016. Building the Foundations - Tackling Obesity through Planning and Development. Public Health England, London.
Town and Country Planning Association (TCPA), 2020. Garden Cities and New Towns London. TCPA. Available from: https://www.tcpa.org.uk/pages/category/garden-cities-and-new-towns.
Twohig-Bennett, C., Jones, A., 2018. The health benefits of the great outdoors: a systematic review and meta-analysis of greenspace exposure and health outcomes. Environ. Res. 166, 628–637.
United Nations, 2020. Mental Health and Development. United Nations [Available from: https://www.un.org/development/desa/disabilities/issues/mental-health-and-development.html.
Van den Berg, M., Wendel-Vos, W., van Poppel, M., Kemper, H., van Mechelen, W., Maas, J., 2015. Health benefits of green spaces in the living environment: a systematic review of epidemiological studies. Urban For. Urban Green. 14 (4), 806–816.
van den Berg, M.M., van Poppel, M., van Kamp, I., Ruijsbroek, A., Triguero-Mas, M., Gidlow, C., et al., 2017. Do physical activity, social cohesion, and loneliness mediate the association between time spent visiting green space and mental health? Environ. Behav. 51 (2), 144–166.
White, M.P., Elliott, L.R., Grellier, J., Economou, T., Bell, S., Bratman, G.N., et al., 2021. Associations between green/blue spaces and mental health across 18 countries. Sci. Rep. 11 (1), 8903.
Wiki, J., Kingham, S., Campbell, M., 2018. Accessibility to food retailers and socio-economic deprivation in urban New Zealand. N. Z. Geogr. https://doi.org/10.1111/nzg.12201, 0(0).
Wilkins, E., Radley, D., Morris, M., Hobbs, M., Christensen, A., Marwa, W.L., et al., 2019. A systematic review employing the GeoFERN framework to examine methods, reporting quality and associations between the retail food environment and obesity. Health Place 57, 186–199.
World Health Organisation, 2017. Urban Green Space Interventions and Health: a Review of Impacts and Effectiveness. WHO, Copenhagen.
World Health Organisation, 2019. Mental Disorders. WHO, Geneva. Available from: https://www.who.int/news-room/fact-sheets/detail/mental-disorders.
World Health Organisation, 2020. WHO Mental Health: Strengthening Our Response Geneva. WHO. Available from: http://www.who.int/mediacentre/factsheets/fs220/en/.