University of Southampton

Faculty of Environment and Life Sciences

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Environmental and Social Factors in Psychosis: The Role of Green Space, Social Functioning and Loneliness.

by

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Thesis for the degree of Doctorate in Clinical Psychology

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Abstract

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There is a growing evidence base recognising the risk reducing effects and potential therapeutic benefits of exposure to green spaces for common mental health problems. Chapter 1 details a systematic review investigating the incidence of schizophrenia spectrum disorders (SSDs) in relation to green space exposure, and the potential benefits of exposure for people with SSDs in terms of health service use and mental health symptoms. Seven databases were searched and twelve studies were eligible for inclusion. Findings suggest that exposure to green spaces reduces the risk of SSDs and these benefits are present from childhood through to adulthood. In addition, there is emerging evidence that exposure to green space can improve mental health symptoms and reduce health service use for people with SSDs. However, quality analysis was mixed for these benefits and studies exploring incidence were conducted mostly in Denmark, therefore these findings may not generalise cross-culturally. Future research is needed to identify the therapeutic "dose" of green space and examine any cross-cultural differences.

Social functioning and loneliness are also implicated within SSDs, with changes to these factors preceding onset of psychosis. However, little research is available which explores the relationships between social functioning, loneliness and prodromal psychosis symptoms within the general population. Chapter 2 presents a longitudinal study examining the relationships between social functioning, loneliness, prodromal symptoms and symptom related distress within a nonclinical sample. Social functioning was negatively associated with prodromal symptoms and distress, and loneliness was positively associated with prodromal symptoms and distress. Loneliness also mediated the effect of social functioning on prodromal symptoms and distress. However, the sample comprised of mostly White, female-identifying, undergraduate students, therefore these results may not generalise to other populations. The findings suggest a need to target social functioning and loneliness as preventative strategies for psychosis within student populations. Future research should determine whether these results can be applied cross-culturally or within at-risk populations.

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Research Thesis: Declaration of Authorship

Print name: LOUISE MARCHAM

Environmental and Social Factors in Psychosis: The Role of Green Space, Social Functioning and Loneliness.

I declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. None of this work has been published before submission. Chapter 1 has been accepted, pending publication.

Signature: Louise Marcham .....Date: 14th May 2024 .....

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Definitions and Abbreviations

CORINE .....Coordination of Information on the Environment

DSM .....Diagnostic and Statistical Manual of Mental Disorders (followed by edition number)

EMA .....Ecological momentary assessment

EPHPP .....Effective Public Health Practice Project

EVI .....Enhanced Vegetation Index

GBD .....Global Burden of Disease

HEART.....Health Equity Assessment and Response Tool

HR .....Hazard ratio

ICD .....International Classification of Diseases (followed by edition number)

IRR .....Incident rate ratio

LIWC.....Linguistic Inquiry and Word Count

NDVI.....Normalised Difference Vegetation Index

NICE.....National Institute for Health and Care Excellence

NHS.....National Health Services

PHE .....Public Health England

PLEs .....Psychotic-like experiences

POMS.....Profile of Mood States

PQ-B.....Prodromal Questionnaire-Brief Version

SSDs.....Schizophrenia spectrum disorders

STAI.....State-Trait Anxiety Inventory

UK .....United Kingdom

WHO .....World Health Organisation

Chapter 1 Exposure to Green Spaces and Schizophrenia: A Systematic Review

The journal 'Psychological Medicine' was selected to guide preparation on the paper. The author guidance (see Appendix I) states that manuscripts must not exceed 4500 words (excluding figures, tables, references, and appendices). This paper has been accepted for publication by the journal.

Word count for the purposes of publication (excludes abstract, tables, figures and reference list): 4500.

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1.1 Abstract

The mental health benefits of exposure to green spaces are well known. This systematic review summarises the evidence of green space exposure for people with schizophrenia spectrum disorders (SSDs), focusing on incidence and mental health outcomes, including mental health symptoms and health service use. The study was pre-registered (PROSPERO ID: CRD42023431954), and conducted according to PRISMA guidelines. Seven databases, reference lists, and grey literature sources were searched. Methodological quality was assessed using The Quality Assessment Tool for Quantitative Studies. 126 studies were screened, and 12 studies were eligible for inclusion. Seven studies found that exposure to green space was associated with a reduced risk of schizophrenia (lowest to highest green space exposure: HRs = 0.62 – 0.37; IRRs = 1.52 – 1.18), with five studies reporting a dose-response relationship. Of these studies, four examined childhood exposure and the remainder examined adult exposure. Regarding health service use, proximity to green space was not significantly associated with length of hospital admission, though greater green space exposure was associated with reduced hospital admission rates. Three studies found reduced symptoms of anxiety (d = -0.70 – 2.42), depression (d = -0.97 – 1.70) and psychosis (d = -0.94) with greater green space exposure. Exposure to green space reduces the risk of schizophrenia, and there is emerging evidence of the potential benefits of green space for reducing symptoms and health service use among people with SSDs. Future research using experimental and longitudinal designs will provide more robust evidence of the benefits of green space for people with SSDs.

Keywords: schizophrenia, psychosis, green space, greenspace, systematic review

1.2 Introduction

There is a growing body of research exploring the relationship between exposure to green space and mental health benefits. In addition, organisations have advocated for the development and protection of green spaces, with the aim of improving population health and wellbeing (World Health Organisation; WHO, 2017; Public Health England [PHE], 2020; Department for Levelling Up, Housing & Communities, 2023). Green spaces can be defined as areas of grass, shrubs, trees, or other vegetation, situated within or adjacent to an urban area (PHE, 2020), and have also been defined by their composition or use, such as nature reserves, parks, forests, and gardens (Taylor & Hochuli, 2017). Exposure to green space generally refers to how often individuals have contact with, or access to, these environments, but can also include single interventions (WHO, 2016). With a growing trend towards urbanisation (United Nations, 2018), there is a need to establish the role of green spaces in conferring mental health benefits, to support the continued integration and maintenance of these areas within urban settings (Barton & Rogerson, 2017; Houlden et al., 2018) and to establish their (potential) therapeutic benefits.

Existing reviews have primarily focused on the benefits of green space in terms of common mental health problems and symptomology. Research has shown that exposure to green spaces is associated with a wide range of mental health benefits (Van den Berg et al., 2010; Alcock et al., 2014; Wendelboe-Nelson et al., 2019; Tran et al., 2022), including improvements in mood and reduced levels of stress and mental fatigue (Bowler et al., 2010; Gascon et al., 2015; Houlden et al., 2018), effects which have been found across the lifespan (McCormick, 2017; Dzhambov, 2018; Pun et al., 2018; Fjaestad et al., 2023). Greater exposure to green spaces has been associated with a reduced risk of developing depression (Min et al., 2017; Brown et al., 2018; Sarkar et al., 2018) and anxiety disorders (Gascon et al., 2018), and has been found to reduce symptoms related to anxiety and depression, suggesting potential protective effects for improving mental health (Pun et al., 2018). Studies have

therefore advocated for the use of green space as an intervention for public mental health (Maas et al., 2006; Soga et al., 2020; Shezi et al., 2024).

The mental health benefits of exposure to green space may also apply cross-culturally, for example forest bathing has been associated with a reduction in mental health symptoms, such as anxiety, in Asia and Europe (Kotera et al. 2020; Park et al., 2022). Forest bathing, or shinrin-yoku, is a relaxation activity originating in Japan that involves observing nature (Miyazaki, 2018). In addition to this, development of community gardens in deprived Cuban communities has been associated with improvements in mental health (Anguelovski, 2013). Residing in areas with greater green space has also been associated with improvements in emotional wellbeing for populations in Ethiopia (Zewdie et al., 2022) and Iran (Yigitcanlar et al. 2020), and a reduction in symptoms of depression for a population in South Africa (Shezi et al., 2024). However, there is a need to further develop research exploring the mental health benefits of green space for populations which are less likely to have access to green spaces (Yigitcanlar et al. 2020; Zewdie et al., 2022; Shezi et al., 2024). Literature to date appears to demonstrate mental health benefits within specific locations, with no further development or synthesis across broader cultures (Shezi et al., 2024).

Exposure to green space could be an effective intervention for managing mental health difficulties. Engaging in activities such as gardening, have resulted in overall improved mental wellbeing and reduction in social isolation (Howarth et al., 2020). For example, accessing horticultural programmes has been associated with improvements for stress-related mental illness and burnout (Adevi & Lieberg, 2012; Sahlin et al., 2014). A systematic review of gardening as a mental health intervention found overall reduced symptoms of anxiety and depression for a clinical population (Clatworthy et al., 2013). Additionally, therapeutic applications of green space have been found to reduce symptoms of clinical depression (Gonzalez et al., 2010; Berman et al., 2012). Other reviews have found that nature walks were associated with a reduction in symptoms of anxiety and depression for clinical and nonclinical populations (Kotera et al., 2021) and, as an intervention for anxiety and depression, resulted

in mental health improvements (Grassini et al., 2022). Access to activities within green spaces have also been found to reduce stress in psychiatric inpatient populations (Vujcic et al., 2017) and have the potential to reduce mental health admissions (Wheater et al., 2007).

Research to date has demonstrated the benefits of exposure to green space for those with depression or anxiety disorders, including within inpatient settings. Existing theories may explain the associations between green space and mental health, for example, attention restoration theory proposes that green space is restorative for brain function, thereby leading to improvements in mood (Kaplan, 1989). Stress reduction theory also proposes that observing nature has stress reducing properties (Ulrich, 1981). Finally, the biophilia hypothesis proposes that humans have an evolutionary connection with nature and are drawn to natural spaces, which aids in their development (Wilson, 1984). Further research is needed to assess the mediating and moderating factors related to green space and mental health improvements, particularly within lower income countries (Nawrath et al., 2020; Shezi et al., 2024). In addition to this, there is a lack of research synthesising the benefits of exposure to green space for risk of severe mental health conditions. Reviews synthesising the therapeutic benefits of exposure to green space, and the service-related benefits for those with severe mental health conditions are limited. Furthermore, there is a lack of synthesis of research exploring the effects of green space for people with schizophrenia spectrum disorders (Tran et al., 2022).

Research has already established a link between urban environments and increased risk of schizophrenia (Vassos et al., 2012), determining the relationship between schizophrenia and green space would expand upon this. Therefore, the aim of this review is to identify and synthesise the evidence of the association of green space and mental health outcomes for people with schizophrenia spectrum disorders (SSDs). Green space interventions are promising due to their relatively low cost and accessibility (Bowen & Parry, 2015; Bowen & Lynch, 2017), with the potential to incur cost savings for the NHS (Wheater et al., 2007). Any identified benefits of green space could provide a rationale for preventative

strategies, alongside integrating aspects of green spaces into therapeutic interventions and mental health services for this population. This review will include quantitative studies that explore the relationship between green space and SSDs and will address the following research questions:

1. What is the association between exposure to green space and the incidence of SSDs?
2. What are the benefits of exposure to green space for individuals with SSDs in relation to: (a) health service use, and (b) mental health symptoms?

1.3 Method

This systematic review was pre-registered on PROSPERO (available at https://www.crd.york.ac.uk/PROSPERO/, ID: CRD42023431954) and conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Page et al., 2021). Databases were initially searched in July 2023, and an updated search was conducted in November 2023 (with no new papers identified). A PRISMA checklist is included as supplementary material (Appendix A).

1.3.1 Inclusion and Exclusion Criteria

Inclusion criteria were: (1) articles of any date, published in English, with findings available; (2) involving exposure to green spaces, with green spaces defined as areas of vegetation (e.g., trees, grass, shrubs), adjacent to or within urban and rural areas, such as parks, gardens, forests, and nature reserves; (3) sample population of people with SSDs; (4) participants of any age (children to older adults); (5) quantitative studies (i.e. cross-sectional, cohort, experimental, correlational, longitudinal) reporting on either the relationship between exposure to green space(s) and SSDs or the benefits of green spaces for SSDs in relation to health service use and/or mental health symptoms; (6) outcomes of interest included reported

risk of SSDs, health service use e.g., admission rates, and symptoms of SSDs and other related mental health outcomes e.g. anxiety, depression, etc.

Exclusion criteria were: (1) qualitative studies; (2) studies that did not include exposure to green space; (3) dissertations or theses; (4) existing reviews.

1.3.2 Search Strategy and Sources of Information

Seven electronic databases were searched, including PubMed (including MEDLINE), Web of Science, PsycARTICLES, APA, PsycINFO, CINAHL, ProQuest, and grey literature sources (EThOS, PsyArXiv, Open Science Framework). The following search terms were adopted: Psychosis OR psychoses OR psychotic OR schiz* OR paranoi* OR delusion* OR hallucinat* **AND** "Green space*" OR "nature contact" OR "urban nature" OR "urban green" OR "nature exposure" OR "nature-based" OR "nature experience" OR "nature sound*" OR "green area*" OR greenspace* OR "natural space*" OR "nature view*"

1.3.3 Screening Process

Articles were initially identified by screening the title, abstract and subject or keywords, followed by full text screening. A second independent rater assessed 20% of all papers identified for full text screening using the outlined eligibility criteria. There were no disagreements between reviewers for study inclusion and exclusion (Cohen's kappa = 1.00). The search strategy and screening process are shown in Figure 1.

1.3.4 Quality Assessment

The included studies were assessed for methodological quality using The Quality Assessment Tool for Quantitative Studies (Effective Public Health Practice Project [EPHPP], 2023). The EPHPP tool provides an overall rating of study methodology using the categories: "strong", "moderate" or "weak", based on individual ratings for eight categories: study design, analysis, withdrawals and dropouts, data collection, selection bias, invention integrity, blinding as part of controlled trials, and confounders. Studies with two or more individual

weak ratings are rated as weak overall. Studies with no weak ratings are rated as strong overall. This tool was used due to its ability to assess articles with a variety of quantitative study designs within the public health domain (Thomas et al., 2004). All of the included studies were rated independently by the first author and an independent rater, and there were no discrepancies in overall study quality ratings.

1.3.5 Data Extraction and Synthesis

The main characteristics of each study and the study population were extracted, alongside data pertaining to the two research questions. A narrative synthesis approach was used, due to heterogeneity in study design, measurement of green space and reported outcomes. Only data relating to SSDs and green spaces were extracted and included in the analysis. Studies were grouped for synthesis according to the research questions they addressed.

1.4 Results

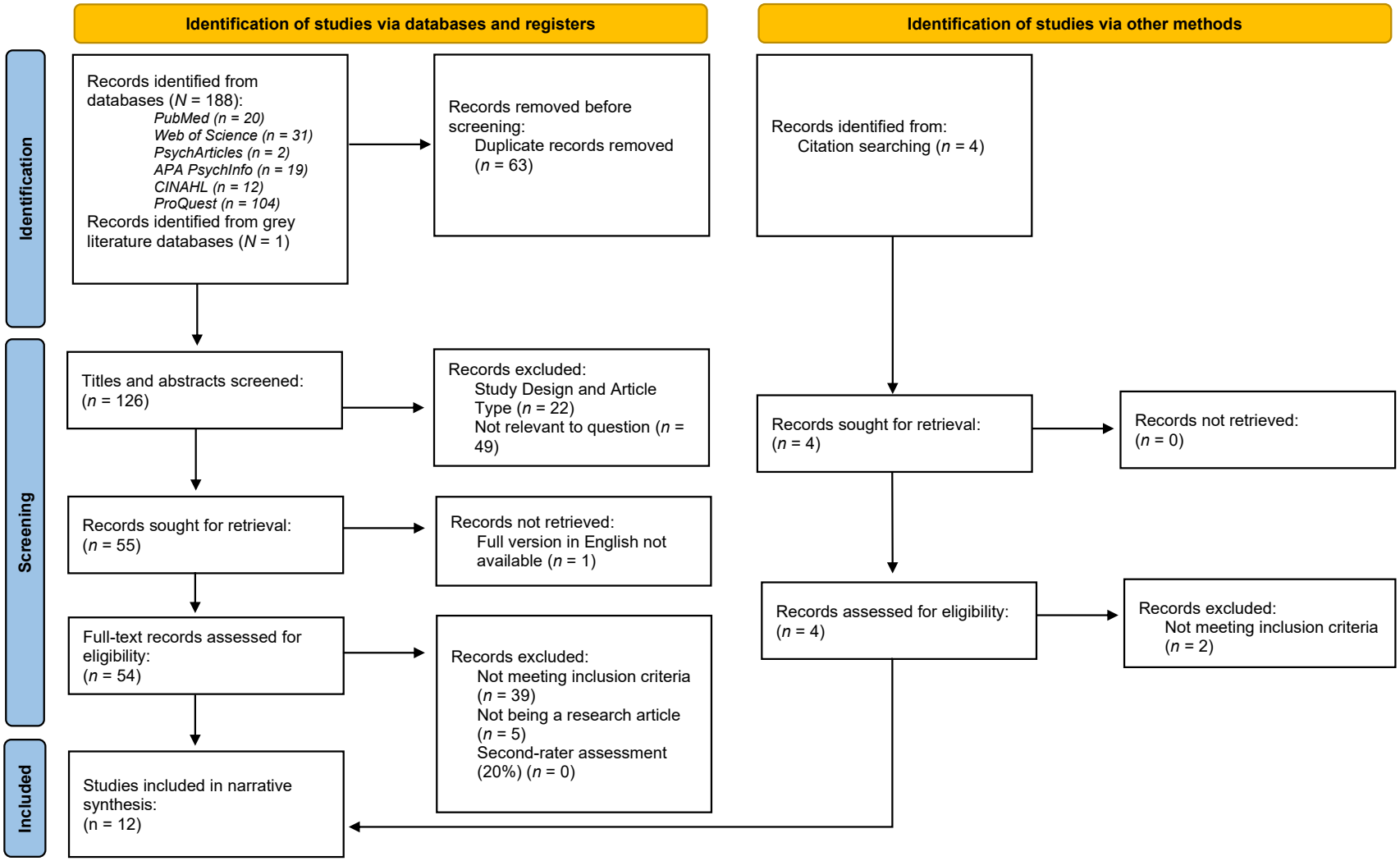
The titles and abstracts of 126 records were screened; 54 records were extracted for full-text evaluation (including one paper from grey literature). Ten studies were eligible for inclusion. An additional two papers were found via searching the reference lists of eligible papers. Therefore, twelve papers were included in the final review (see Table 1 for a summary of study characteristics).

1.4.1 Characteristics of Included Studies

The total number of participants with SSDs across all studies was 50,708. The studies were conducted in seven countries: Denmark ($k = 4$), Taiwan ($k = 2$), the USA ($k = 2$), Canada ($k = 1$), Germany ($k = 1$), the Netherlands ($k = 1$), and Poland ($k = 1$). Study designs included cohort ($k = 9$), cross-sectional ($k = 2$), and quasi-experimental ($k = 1$). Seven studies explored the incidence rates of SSDs in relation to green spaces, and five studies explored the effect of green spaces on individuals with SSDs in relation to mood ($k = 3$), anxiety ($k = 3$),

Figure 1.

PRISMA flowchart



symptoms of psychosis (k = 1), hospital admission rates (k = 1), and length of hospital admission (k = 1).

1.4.1.1 Sample Characteristics

Four studies reported descriptives for gender for people with SSDs (Boers et al., 2018; Bielinis et al., 2020; Henson et al., 2020; Kangarloo et al., 2023), with a tendency towards male participants (range of 51 - 75%). Only two studies reported on participant ethnicity (Henson et al., 2020; Kangarloo et al., 2023), the samples were reported primarily as "White / Caucasian" (35 – 54.3%). Four studies reported age descriptives, with ages ranging from 0-94 years ($\mu\bar{x}$ = 42.87, ± 13.82) (Boers et al., 2018; Bielinis et al., 2020; Henson et al., 2020; Kangarloo et al., 2023).

1.4.1.2 Measurement of Green Space

For studies exploring schizophrenia incidence, green space was quantified using five metrics: (1) normalised difference vegetation index (NDVI), a metric used to capture the presence and density of green vegetation over a patch of land (Engemann et al., 2018; Chang et al., 2019; Chang et al., 2020; Engemann et al., 2019; Engemann et al., 2020a; Engemann et al., 2020b). NDVI calculations range from -1 to 1, where a value of 1 indicates the highest density of green cover (The National Aeronautics and Space Administration [NASA], 2000); (2) enhanced vegetation index (EVI) , a more sensitive measure of green space, in which calculations range from 0 to 1, where 1 indicates the greatest density of healthy green vegetation (Chang et al., 2020); (3) categories of green space (e.g., forest and recreational green spaces) and descriptors of green space (e.g., area size, connectedness of spaces) (Engemann et al., 2018; Chang et al., 2020); (4) land cover from the Coordination of Information on the Environment (CORINE; European Environmental Agency, 2023), a database which classifies land cover according to categories ranging from urban green spaces to dense urban / industrial land use (Engemann et al., 2020a); and (5) The Urban Health

Equity Assessment and Response Tool (Urban HEART; Centre for Research in Inner City Health, 2014), which provides a measure of neighbourhood-level green space, calculating the average amount of green space per km2 in a circular buffer around residential areas, based on geospatial data (Rotenberg et al., 2022).

For studies exploring the benefits of exposure to green spaces for SSDs in relation to health service use and/or mental health symptoms, one study measured green space exposure as a forest recreation intervention (walking, stretching, watching landscapes) (Bielinis et al., 2020). Two studies measured the percentage of agricultural, forest and natural areas within a circular buffer of patients' home addresses, using land databases (Losert et al., 2012; Boers et al., 2018). Two studies matched GPS locations from participants' mobile phones to NDVI data (Henson et al., 2020; Kangarloo et al., 2023).

1.4.1.3 Measurement of Schizophrenia and Mental Health Symptoms

SSDs were quantified using the following: (1) the International Classification of Diseases (ICD-8, ICD-9, ICD-10; WHO, 1968-1993) (Losert et al., 2012; Engemann et al., 2018; Chang et al., 2019; Engemann et al., 2019; Bielinis et al., 2020; Chang et al., 2020; Engemann et al., 2020a; Engemann et al., 2020b; Rotenberg et al., 2022); and (2) the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV, DSM-V; American Psychiatric Association, 1994-2001) (Boers et al., 2018; Henson et al., 2020; Kangarloo et al., 2023).

Other symptoms measured to assess the mental health benefits of green spaces included: (1) the Profile of Mood States (POMS; Dudek & Koniarek, 1987) (Bielinis et al., 2019); (2) the State-Trait Anxiety Inventory, state anxiety measure only (STAI-S; Spielberger et al., 1983) (Bielinis et al., 2019); (3) ecological momentary assessment (EMA; Shiffman et al., 2008), containing symptom questionnaires relating to anxiety and depression (Henson et al., 2020; Kangarloo et al., 2023), as well as symptoms of psychosis (Henson et al., 2020); (4)

Linguistic Inquiry and Word Count (LWIC) for affect expression (Pennebaker et al., 2015) (Kangarloo et al., 2023).

1.4.1.4 Measurement of Health Service Use

Health service use was quantified by: (1) length of hospital admission in days (Boers et al., 2018); and (2) psychiatric hospital admission rates, calculated by the number of admissions per location and analysed as incidence rate ratios (IRRs). Only the first admission for each patient was counted and patients were excluded if their place of residence was unclear (Losert et al., 2012).

1.4.1.5 Quality Analysis

After quality assessment, six of the included studies were rated as "strong" (Engemann et al., 2018; Engemann et al., 2019; Chang et al., 2020; Engemann et al., 2020a; Engemann et al., 2020b; Rotenberg et al., 2022), four were rated as "moderate" (Chang et al., 2019; Bielinis et al., 2020; Henson et al., 2020; Kangarloo et al., 2023), and two were rated as "weak" (Losert et al., 2012; Boers et al., 2018).

1.4.2 Main Findings

A summary of the studies included in the review is provided in Table 1.

1.4.2.1 What is the association between exposure to green space and the incidence of SSDs?

Seven studies, all with a cohort design, explored the incidence rate of SSDs in relation to exposure to green spaces. Four studies took a developmental approach, focusing on childhood exposure to green spaces and risk of later development of SSDs (Engemann et al., 2018; Engemann et al., 2019; Engemann et al, 2020a; Engemann et al., 2020b), whilst the remainder focused on adult exposure to green spaces. After quality analysis, six studies were rated as "strong" and one was rated as "moderate". Four studies calculated risk of SSDs using

Table 1.

Summary of studies and quality analysis

Author (Year)	Country	Study Design	Total Sample Size (schizophrenia)	Green space measure or intervention	Outcome(s) of interest	Covariates Measured	Quality Assessment	Findings (related to schizophrenia spectrum disorders)
Bielinis et al. (2020)	Poland	Quasi-experimental	50 (23)	1 hour 45 minutes of forest recreation intervention (walking, stretching, watching, landscapes).	Profile of Mood States (POMS). State-Trait Anxiety Inventory (STAI-S only).	None described.	Moderate	POMS: A significant decrease in tension-anxiety (d = 1.30), depression-dejection (d = 1.70), confusion (d = 2.01) and anger-hostility (d = 1.10) post intervention. A significant increase in vigour (d = 2.46) post intervention. No change in fatigue. STAI-S: A significant decrease in anxiety levels (d = 2.42) post intervention.
Boers et al. (2018)	The Netherlands	Cross-sectional	623 (623)	Percentage of agricultural, forest and natural areas (using Dutch land use database) within a circular buffer of 300m	Length of hospital admission (days).	Gender, age, urbanicity, socioeconomic status (individual).	Weak	Green space was not significantly correlated with length of hospital admission (Model 1: t = 0.232, p = 0.817; Model 2: t = 0.321, p = 0.748).

				around patient's home address.				
Chang et al. (2019)	Taiwan	Cohort study	869,484 (5069)	Normalised difference vegetation index (NDVI). *Higher values indicate greater healthy green vegetation.*	Schizophrenia incidence.	Gender, age, meteorological, health insurance rate.	Moderate	A significant negative association between surrounding greenness and schizophrenia risk ($p < 0.05$), with HRs reducing as NDVI increased from the 75th percentile onwards (Hazard ratio [HR] = 0.49, 95% confidence interval [CI] = 0.37 – 0.65; HR = 0.41, 95% CI = 0.30 – 0.56; HR = 0.41, 95% CI = 0.30 – 0.55; HR = 0.37, 95% CI = 0.25 – 0.55). The protective effects of green space were significant for both cities (HR = 0.22, 95% CI = 0.06 – 0.81) and metropolitan areas (HR = 0.46, 95% CI = 0.25 – 0.85).
Chang et al. (2020)	Taiwan	Cohort study	1,918,501 (3823)	NDVI and Enhanced vegetation index (EVI). Green space categories: 1) Forest	Schizophrenia incidence.	Gender, age, urbanicity, socioeconomic status (individual), meteorological, air pollution,	Strong	Overall greenness associated with lower HRs for schizophrenia incidence (NDVI: HR = 0.79, 95% CI = 0.49 – 1.27; EVI: HR = 0.57, 95% CI = 0.27 – 1.19).

				2) Recreational Descriptors of green spaces: 1) Mean patch area 2) Contiguity index 3) Aggregation index		health insurance rate.		A larger mean patch area[1], higher contiguity index[2], and higher aggregation index[3] were associated with HRs < 1 for schizophrenia incidence, except for mean patch area in recreational green spaces (HR = 1.01, 95% CI = 0.97 – 1.05).
Engemann et al. (2018)	Denmark	Cohort study	943,027 (7609)	1) mean green space, 2) spatial heterogeneity of green space. NDVI at $30m^2$ resolution from Landsat archive.	Schizophrenia incidence.	Gender, age, socioeconomic status (individual).	Strong	Living at the lowest amount of green space was associated with a 1.52 (95% CI = 1.36 - 1.69, p <0.000) fold increased risk of developing schizophrenia (IRR), compared to living at the highest level of green space. There was a dose-response relationship for exposure to green space at age 10 and risk

[1] Size of greenspace area and edge
[2] Connectedness of greenspaces within a location
[3] Proximity to greenspace

								of schizophrenia, with risk reducing as exposure increased. This association remained after adjusting for known risk factors for schizophrenia (urbanization, socioeconomic status, sex).
Engemann et al. (2019)	Denmark	Cohort study	943,027 (16,832)	NDVI at 30m resolution from Landsat archive.	Incidence of psychiatric disorders (including schizophrenia, schizoaffective disorders, and schizophrenia and related disorders).	Urbanicity, parental age, socioeconomic status (parental), mental health history (parental), socioeconomic status (neighbourhood).	Strong	Incident rate ratio (IRR) was higher for lowest NDVI compared to highest levels of NDVI for schizophrenia and schizophrenia and related disorders, but not for schizoaffective disorder (IRR = 1.33; 95% CI = 0.98 - 1.82). There was a dose-response relationship between IRR and NDVI for schizophrenia and schizophrenia and related disorders, with risk declining as NDVI levels increased.
Engemann et al. (2020a)	Denmark	Cohort study	943,027 (7609)	Two indicators: 1) land cover (Coordination of Information on the Environment;	Schizophrenia incidence.	Gender, age, socioeconomic status (individual), mental health	Strong	HRs for schizophrenia showed decreased rates for children growing up in environments with more natural features, compared to children growing up in urban environments (agriculture HR = 0.69, 95%

				CORINE) and 2) vegetation density (NDVI)		history (parental), socioeconomic status (neighbourhood).		CI = 0.66 - 0.71; near-natural green space HR = 0.74, 95% CI = 0.63 - 0.88). There was a dose-response relationship for children growing up with near-natural green space as the most frequent land cover class.
Engemann et al. (2020b)	Denmark	Cohort study	19,746 (2636)	Mean yearly NDVI within square-shaped zones of 210 m × 210 (from birth to 10 years old)	Schizophrenia incidence.	Gender, age, socioeconomic status (individual), mental health history (parental).	Strong	Increasing NDVI was associated with decreased risk of schizophrenia (adjusted HR = 0.52, 95% CI = 0.40 - 0.66). Individuals in the highest NDVI exposure had a lower risk of developing schizophrenia (HR = 0.62, 95% CI: 0.48 to 0.80), compared with individuals with the lowest NDVI.
Henson et al. (2020)	USA	Cohort study	63 (37)	GPS locations from smartphones matched to NDVI.	Ecological momentary assessment (EMA) survey which measured anxiety, depression, sleep,	Gender, age, socioeconomic status (individual), socioeconomic	Moderate	Schizophrenia group: High NDVI settings were associated with significantly lower symptoms for anxiety (d = -0.70, p < 0.001), depression (d = -0.97, p < 0.001), and

					sociability, and psychotic symptoms.	status (neighbourhood), population density.		psychosis (d = -0.94, p < 0.001), compared to low NDVI settings. Schizophrenia group: High NDVI settings were associated with better sleep (d = -0.54, p < 0.001) but worse levels of sociability (d = 0.55, p < 0.001).
Kangarloo et al. (2023)	USA	Cohort study	35 (20)	Geo-locations from smartphones matched to NDVI.	EMA survey measuring emotional experiences using scales for happiness, sadness and anxiety. Affect expression in speech using Linguistic Inquiry and Word Count (LWIC).	Gender, age, education, employment status.	Moderate	Small to moderate associations between greater greenspace exposure and lower average sadness (ρ = -0.05) and anxiety (ρ = -0.25) across the study duration. A moderate association between greater overall greenspace exposure and a lower proportion of negative affect words (ρ = -0.29). Specifically anxious (ρ = -0.26) and anger (ρ = -0.37) words. No significant daily associations between greenspace exposure and measures of anxiety or sadness, and negative affect words spoken.

Losert et al. (2012)	Germany	Cross-sectional	4198 (1586)	Percentage of forest area and percentage of agricultural area.	Admission rates.	Distance between town and psychiatric hospital.	Weak	An increase in surrounding agricultural land by 1% is related to a decrease in admissions by 4.3% (IRR = 0.96; *p* = 0.049). Findings for increases in forest area in relation to admission rates were not significant (IRR = 0.96. *p* = 0.076).
Rotenberg et al. (2022)	Canada	Cohort study	649, 020 (4841)	The Urban Health Equity Assessment and Response Tool (Urban HEART) measure of neighbourhood-level green space.	Schizophrenia incidence.	Gender, age, socioeconomic status (neighbourhood).	Strong	Neighbourhoods with lowest amount of green space had a 24% higher risk of developing schizophrenia (adjusted IRR = 1.24, 95% CI = 1.06 – 1.45), compared to neighbourhoods with the highest amount of green space.

hazard ratios (HRs), where a HR < 1 indicates beneficial effects of green space exposure for reducing the risk of SSDs. Three studies calculated relative risk of SSDs using incidence rate ratios (IRRs), to measure differences between low and high greenspace exposure. IRRs were calculated from measuring differing levels of green space exposure and associated incidence rates for SSDs, with higher IRRs indicating a greater risk of SSDs. IRRs > 1 indicated an increased risk from exposure, IRRs equal to 1 indicated no difference, and IRRS < 1 indicated beneficial effects of green space exposure.

Exposure to green space is associated with a reduced risk of schizophrenia. Studies reported reductions in schizophrenia risk for individuals with greater green space exposure, with HRs ranging from 0.62 for the lowest green space exposure (Engemann et al., 2020b), to 0.37 for the greatest greenspace exposure (Chang et al., 2019). Living in areas with the lowest concentration of green space was associated with an increased risk of developing schizophrenia (IRRs = 1.52 and 1.24), compared to living within the highest concentration of green space (Engemann et al., 2018; Rotenberg et al., 2022). One study found that overall neighbourhood greenness, such as forests and recreational green spaces, was associated with lower HRs for schizophrenia incidence (NDVI HR = 0.79, EVI HR = 0.57) (Chang et al., 2020). HRs were found to be lower for children who had grown up in environments with near-natural features (i.e., vegetation ranging from grasslands to forests, containing human influences, such as benches and pathways), compared to those growing up in environments with urban as the most frequent land cover category (HRs = 0.69 – 0.74) (Engemann et al., 2020a), and HRs were lower for greater exposure to green space (HR = 0.62), compared to those with the lowest exposure (Engemann et al., 2020b). Regarding specific psychiatric diagnoses, one study found that the reduced risk only applied to schizophrenia and schizophrenia-related disorders for greater green space exposure, this effect was not found for schizoaffective disorders (Engemann et al., 2019). In addition to these findings, one study reported potential protective effects of exposure to green spaces within cities (HR = 0.22) and

metropolitan areas (HR = 0.46), with increased areas of green space within these locations associated with reduced HRs (Chang et al., 2019).

Associations remained across all studies after controlling for a number of covariates for schizophrenia risk, including: gender (Engemann et al., 2018; Chang et al., 2019; Chang et al., 2020; Engemann et al., 2020a; Engemann et al., 2020b; Rotenberg et al., 2022), age (Engemann et al., 2018; Engemann et al., 2019; Chang et al., 2019; Chang et al., 2020; Engemann et al., 2020a; Engemann et al., 2020b; Rotenberg et al., 2022), health (Chang et al., 2019; Chang et al. 2020), meteorological factors (Chang et al., 2019; Chang et al., 2020), air pollution (Chang et al., 2020), health insurance rates (Chang et al., 2019; Chang et al., 2020), individual socioeconomic status (Engemann et al., 2018; Chang et al., 2020; Engemann et al., 2020a; Engemann et al., 2020b), parental socioeconomic status (Engemann et al., 2019; Engemann et al., 2020b), neighbourhood-level socioeconomic status (Engemann et al., 2019; Engemann et al., 2020a; Rotenberg et al., 2022), urbanicity (Engemann et al., 2019; Chang et al., 2020), and family mental health history (Engemann et al., 2019; Engemann et al., 2020a) (see Table 1). It is worth noting that only two studies controlled for urbanicity, therefore we cannot confidently determine whether these findings were influenced by urbanicity.

There may be a dose-response relationship between exposure to green space and schizophrenia risk. Three studies reported a dose-response relationship between exposure to green space and schizophrenia risk, with risk reducing as exposure to green space increased (Engemann et al., 2018; Engemann et al., 2019; Engemann et al., 2020a), IRRs ranged from 1.52 at the lowest green space exposure to 1.18 at the highest green space exposure (Engemann et al., 2018). The studies controlled for the following covariates related to schizophrenia risk: gender (Engemann et al., 2018; Engemann et al., 2020a), age (Engemann et al., 2018; Engemann et al., 2019; Engemann et al., 2020a), individual socioeconomic status (Engemann et al., 2018; Engemann et al., 2020a), parental socioeconomic status (Engemann et al, 2019), neighbourhood socioeconomic status (Engemann et al., 2019), and parental mental health history (Engemann et al., 2020a). Only one study controlled for urbanicity

(Engemann et al., 2019). These studies were rated as "strong" in methodological quality, suggesting we can be relatively confident in these associations. Increasing green space density and cover was associated with a decreased risk of schizophrenia (HR = 0.62) (Engemann et al., 2020b), with larger green spaces and greater proximity to green space associated with HRs < 1 (Chang et al., 2020). Again, these studies were rated as "strong" in methodological quality and the authors controlled for gender (Chang et al., 2020; Engemann et al., 2020b), age (Chang et al., 2020; Engemann et al., 2020b), individual socioeconomic status (Engemann et al., 2020b; Chang et al., 2020), parental mental health history (Engemann et al., 2020b), health insurance rates (Chang et al., 2020), pollution (Chang et al., 2020) and meteorological factors (Chang et al., 2020). Only one study controlled for urbanicity (Chang et al., 2020). Another study reported a significant negative association between surrounding greenness and schizophrenia risk, with HRs ranging from 0.49 to 0.37 as green space density increased (Chang et al., 2019). This study was rated as "moderate" in methodological quality and controlled for gender, age, health insurance rate and meteorological factors.

1.4.2.2 What are the benefits of exposure to green space for individuals with SSDs in relation to (a) health service use and (b) mental health symptoms?

Five studies explored the benefits of exposure to green space for individuals with SSDs. Two studies used a cross-sectional design (Boers et al., 2018; Losert et al., 2012), two studies used a cohort design (Henson et al., 2020; Kangarloo et al., 2023), and one study used a quasi-experimental design (Bielinis et al., 2020). After quality analysis, three studies were rated as "moderate" (Bielinis et al., 2019; Henson et al., 2020; Kangarloo et al., 2023) and two were rated as "weak" (Boers et al., 2018; Losert et al., 2012).

(a) Health service use. The two cross-sectional studies explored proximity to green space in relation to: (1) length of hospital admission (Boers et al., 2018), and (2) percentage of forest and agricultural areas in relation to admission rates for schizophrenia, calculated using IRRs (Losert et al., 2012). After controlling for gender, age, urbanicity and individual

socioeconomic status, the findings suggest that proximity to green space was not significantly correlated with length of hospital admission (Boers et al., 2018). However, this study was rated as "weak" in methodological quality and therefore these findings should be cautiously interpreted. The remaining study found a significant relationship between increases in the proportion of surrounding agricultural land and decreases in admission rates for people with SSDs (IRR = 0.96, $p = 0.049$) (Losert et al., 2012). This was after controlling for the distance between towns and psychiatric facilities. This study was also rated as "weak" in methodological quality and should be cautiously interpreted.

(b) Mental health symptoms. One cohort study measured symptoms of anxiety, depression, sleep, sociability, and psychotic symptoms amongst people with SSDs over the course of three months, using EMA surveys accessed via mobile phone (Henson et al., 2020). GPS locations were collected alongside completion of the EMA, to measure green space cover and density. The analyses controlled for gender, age, individual socioeconomic status, neighbourhood socioeconomic status and population density. The study reported significantly lower symptoms for anxiety ($d = -0.70$), depression ($d = -0.97$) and psychosis ($d = -0.94$), and better sleep ($d = -0.54$) for settings with high levels of green space, compared to settings with low levels of green space. This study was rated as "moderate" for its methodological quality.

Another cohort study measured emotional experience (happiness, sadness, and anxiety) and positive and negative speech affect (including negative affect subcategories: anxiety, anger, and sadness) over the course of seven days using EMA surveys accessed via mobile phones (Kangarloo et al., 2023). Data were collected three times a day at set times (10:00-13:00, 14:00-17:00, 17:00-20:00), and geolocations were collected alongside EMA data to measure green space cover and density. The analyses controlled for gender, age, education and employment status. Results suggested small to moderate associations (rho values between –0.22 and –0.32) between greater green space exposure and lower scores for sadness and anxiety, across the seven days. There was also a moderate association ($\rho = -0.29$) between greater overall green space exposure and lower proportions of negative affect words

used across the week, such as anxiety (ρ = -0.26) and anger words (ρ = -0.37). However, these findings were not significant at the daily level. This study was also rated as "moderate" for its methodological quality.

Finally, in a quasi-experimental study, 23 participants with SSDs participated in a forest recreation intervention, consisting of a one hour and 45-minute walk in nature, with stretching and watching landscapes (Bielinis et al., 2020). The study captured pre and post-intervention scores using the profile of mood states (POMS) and the State-Trait Anxiety Inventory (STAI-S only). Significant decreases in all mood states of the POMS (except for vigour, which increased, and fatigue, where there were no changes) were found following the forest recreation intervention. There was also a significant decrease in anxiety levels (STAI-S), post intervention with a large effect size (d = 2.42). This study was rated as "moderate" for its methodological quality, however the analyses did not control for potential covariates.

1.5 Discussion

This review aimed to synthesise the findings from quantitative studies that explored exposure to green space, incidence rates of SSDs and benefits for people with SSDs in relation to health service use and mental health symptoms. Twelve studies were included in the review, of which seven explored associations between green space exposure and SSD incidence, and five explored the benefits of green space exposure for people with SSDs.

Overall, the findings suggest that exposure to green space is associated with a reduced risk of SSDs, with some evidence that there may be a dose-response relationship. Childhood exposure to green space may also reduce the risk of SSDs later on. The quality of evidence was mostly high for these studies ("strong" and "moderate"), and sample sizes were large, suggesting that we can be relatively confident in these conclusions. These studies also controlled for a range of covariates within their analyses, although it is worth noting that only two studies controlled for urbanicity. This supports existing literature reporting an association between green space exposure and reduced risk of depression and anxiety disorders (Min et

al., 2017; Brown et al., 2018; Gascon et al., 2018; Sarkar et al., 2018). This body of evidence, taken together with the findings from the current review, provides clear evidence of the benefits of green space exposure in terms of reducing the risk of mental health diagnoses.

The studies in this review used a range of methods to explore the benefits of green space exposure, including cohort, cross-sectional and quasi-experimental designs. They report a range of benefits from green space exposure for people with SSDs, including improved mood, and reduced symptoms of anxiety and psychosis, as well as reductions in hospital admission rates. A strength of this body of literature is that a range of assessment methods have been used (e.g. EMA) such that it is not constrained by the sole use of self-report. However, the overall quality of the evidence was weaker (two studies were rated as "weak"), sample sizes were much smaller, one study did not include covariates within their analyses, and none of the studies controlled for urbanicity. This suggests that we should be appropriately cautious when interpreting these findings. Nevertheless, these findings support existing literature showing that exposure to green space reduces symptoms of anxiety and depression (Gonzalez et al., 2010; Berman et al., 2012; Kotera et al., 2021) and reduces length of psychiatric hospital admissions (Wheater et al., 2007). Despite the limitations in quality, these studies offer promising implications of the potential benefits of green space exposure for people with SSDs, which should be investigated further in future research to provide more robust evidence.

Collectively, the findings from the review provide support for the need to integrate and maintain green spaces as a public health intervention (Maas et al., 2006; Soga et al., 2020). Benefits reported from increasing surrounding green space suggests that planning should take into account the proportion of available green spaces within urban settings, with increases in green spaces having risk-reducing effects for SSDs. Given the reported risk-reducing effects of childhood exposure to green spaces from the current review, measures could include increasing access to green spaces for children, such as parks and recreational

activities within green spaces. In addition, people with SSDs may benefit from access to green space interventions, such as horticulture programmes, walks and other activities in nature, as demonstrated for other mental health conditions (Clatworthy et al., 2013; Kotera et al., 2021; Grassini et al., 2022).

1.5.1 Limitations

Regarding the literature included in the review, the evidence for the benefits of green space exposure for SSDs in relation to health service use and symptom reduction is emerging, such that the conclusions from this review are limited by the small number of studies available and the weaker quality of evidence, and findings are yet to be replicated. In addition, only two studies within the review reported on ethnicity, where the samples were majority White, and studies exploring incidence rates were mostly conducted in Denmark. Therefore, these results may not be generalisable cross-culturally.

The available studies did not include countries with limited green space cover, such as desert areas, mountainous areas, or populations where there is primarily blue space cover. Therefore, these results may not be generalisable to populations within arid areas, where plant growth is scarce. Blue space has also been associated with mental health benefits (Smith et al., 2021), and participant access to blue space areas were not controlled for within the included studies. Therefore we cannot determine whether blue space exposure could have contributed to these effects. Additionally, only populations from high-income countries were sampled within the included studies. This adds to the existing argument for developing research within low and middle income countries, to see if these effects are maintained (Nawrath et al., 2020; Shezi et al., 2024).

It is also important to consider limitations of the review process. Omission of search terms for the full range of SSD symptoms may have biased results in favour of positive symptoms. Future studies should include search terms which encompass all dimensions of

SSDs, including negative symptoms. In addition, the search terms for green spaces could be expanded to include components of green space, such as parks, forest, woodlands, gardens, etc., to potentially increase eligible studies. Finally, this review did not investigate possible causes of heterogeneity for study results or complete sensitivity analyses, therefore the review is not able to determine the robustness of results beyond quality assessment.

1.5.2 Recommendations for Future Research

This review highlights the need to develop the evidence base for the benefits of green space exposure for individuals with SSDs. It is notable that only one published study to date has used an experimental design to examine in vivo green space exposure and the effects on a range of mental health symptoms. Larger scale studies are needed to assess the benefits of exposure to green space using both experimental and longitudinal designs, examining a broader range of outcomes that are not solely focused on symptom reduction, including wellbeing and recovery, and to determine the "dose" of green space exposure that is needed to produce clinically-significant change. Future studies are needed to understand the components of green space that might be particularly beneficial, to identify the mechanisms through which green space interventions work, and finally to identify the factors that might act as moderators to determine who might benefit most from green space interventions. Additionally, examining cross-cultural differences in green space exposure and SSDs should be a research priority, as well as determining whether the findings linking green space exposure and incidence rates for SSDs are replicated in other countries, including low and middle income countries, and those with limited natural green space cover.

1.5.3 Conclusion

Exposure to green space within both childhood and adulthood has risk reducing effects for the occurrence of SSDs, with some evidence for a dose response relationship. There is emerging evidence for the potential therapeutic benefits of exposure to green space for

symptom reduction in people with SSDs and reduced health service use. Future research is needed to identify the optimal therapeutic "dose" of green space exposure, to identify mediators and moderators of green space interventions and examine any cross-cultural differences.

1.6 Contributors

Study design and protocol (LM, LE); literature searches and summaries (LM); data extraction (LM); data synthesis (LM; LE); writing original draft (LM); editing (LM, LE).

1.7 Data Availability Statement

The datasets used during the review are available from the corresponding author on request.

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Chapter 2 Loneliness as a Mediator between Social Functioning and Prodromal Psychosis Symptoms Over Time

The journal 'Mental Health and Prevention' was selected to guide preparation on the paper. The author guidance (see Appendix J) states that manuscripts must not exceed 5000 words (excluding figures, tables, references, and appendices).

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2.1 Abstract

Social functioning and loneliness are implicated in psychotic disorders and research suggests that changes to these factors precede psychosis onset. However, little is known regarding the relationships between social functioning, loneliness and prodromal experiences in a non-clinical population. This study used a longitudinal design over 6 to 8 months with three time points (Time 1: baseline, Time 2: 3-4 months, Time 3: 6-8 months) to examine the relationship between social functioning, loneliness and prodromal symptoms and symptom-distress within a non-clinical sample (N = 276). Social functioning was negatively associated with prodromal symptoms and symptom-distress (r = -.42, -.52). Loneliness was positively associated with prodromal symptoms and symptom-distress (r = .40, .43). Loneliness also mediated the effect of social functioning and prodromal symptoms (β = -.039, bootstrapped 95% CI = -.082, -.005) and symptom-distress (β = -.035, bootstrapped 95% CI = -.087, -.002). These results suggest that lower social functioning leads to greater loneliness which in turn leads to increased prodromal symptoms or symptom-distress. The findings suggest the need to target social functioning and loneliness within preventative strategies for psychosis. Future studies should determine if these results apply cross-culturally and hold within at risk and younger populations.

Keywords: schizophrenia, psychosis, social functioning, loneliness, students, prodromal

2.2 Introduction

Psychosis is amongst the leading causes of disability worldwide (Global Burden of Disease [GBD] 2021 Collaborators, 2024), with high intervention costs and relapse rates (Robinson et al., 1999; Schizophrenia Commission, 2012; Charlson et al., 2018). Early detection and intervention are therefore vital to implement preventative strategies and improve long term outcomes (McGlashan et al., 2001; Loewy et al., 2011). This includes identifying prodromal symptoms within the general population, as these can predict the transition into psychosis (Miller at al., 2002; McGorry et al., 2003; Schultze-Lutter et al., 2012; Fusar-Poli et al., 2013). Up to 20% of the adult population can experience psychotic-like experiences (PLEs) without a diagnosis (Hanssen et al., 2003), and the first episode of psychosis is often preceded by a prodromal period (Jackson et al., 1995; Häfner, 2000; Häfner et al., 2003). The prodrome is defined as period of experiencing gradual changes in thoughts, behaviours, perceptions, and functioning (Yung et al., 1996; Häfner et al., 1998). This often starts with nonspecific clinical symptoms, e.g., social withdrawal; leading to basic symptoms, e.g., suspiciousness; and following on to positive symptoms (Cornblatt et al., 2003; Phillips et al., 2005; Schultze-Lutter et al., 2010).

Symptom-related distress is a key factor within the prodromal period (Loewy & Cannon, 2010), risk for psychosis is greater when individuals are distressed by their experiences, compared to those who are not (Hanssen et al., 2003; Oh et al., 2023). Symptom-related distress is a significant cause for seeking treatment and receiving a diagnosis of psychosis (Johns & Os, 2001). Distress often leads to social isolation which can reinforce paranoid beliefs and distress (Freeman et al., 2007), exacerbating psychosis symptoms (Häfner et al., 2003; Tully et al., 2017). Social impairment has also been identified within the prodromal period and early stages of psychosis as a potential risk factor (Häfner et al., 1998; Malmberg et al., 1998; van Os et al., 2000; Boydell et al., 2004; Gayer-Anderson & Morgan, 2013), with social withdrawal reported as commonly occurring before psychosis onset (Yung

et al., 1996; Mäki et al., 2014). Individuals experiencing psychosis also report reduced social networks and reduced social contact (Macdonald et al., 2000; Reininghaus et al., 2008). Social isolation has been suggested to maintain psychosis symptoms due to lack of opportunities to disconfirm or review beliefs with others within social networks (Garety et al., 2001; Freeman & Garety, 2006; Freeman, 2007). Social processes are therefore important to consider alongside prodromal symptoms, as potential targets for prevention strategies (Häfner et al., 2003; Fusar-Poli, 2021).

Social functioning is defined as one's ability to interact effectively across different social contexts e.g., work, education, leisure, family (Mueser & Tarrier, 1998; Hooley, 2010). Deficits in social functioning are a core feature of psychosis (Bellack et al., 2007), leading to poor outcomes (Bellack et al., 1990; Hooley, 2010). Consequently, current interventions focus on improving social functioning for individuals with psychosis (Turner et al., 2018). However, impairments in social functioning have been found long before psychosis onset (Addington et al., 2008; Cornblatt et al., 2012). Poorer social functioning has been associated with greater prodrome symptom severity in groups at high risk of developing psychosis (Robustelli et al., 2017), and PLEs in the general population (Pelletier et al., 2013). Early social functioning deficits are also predictive of psychosis onset (Davidson et al., 1999; Addington & Addington, 2005; Cornblatt et al., 2007; Carrión et al., 2021), as well as worse social outcomes for those with psychosis, such as increased isolation and loneliness (Velthorst et al., 2017; Nevarez-Flores et al., 2022). Longitudinal studies are therefore needed to explore the role of social functioning and loneliness in relation to prodromal symptoms and distress (Addington et al., 2008; Addington et al., 2019).

Individuals with psychosis also experience higher levels of loneliness compared to the general population (Badcock et al., 2015), with positive symptoms associated with higher levels of loneliness (Angell & Test, 2002). Loneliness is associated with increased PLEs for those at risk of psychosis (Raposo de Almeida et al., 2024), and may be a risk factor for psychosis onset (Michalska da Rocha et al., 2018; Mäki et al., 2014; Sündermann et al.,

2014). Those at risk of developing psychosis report higher levels of loneliness compared to controls (Robustelli et al., 2017), and increased loneliness can lead to PLEs within the general population (Freeman et al., 2008; Le et al., 2019; Narita et al., 2020; Lincoln et al., 2021). Loneliness may impede psychosis recovery by maintaining symptoms (Gayer-Anderson & Morgan, 2013; Badcock et al., 2019). Loneliness is a clinically relevant issue for the prodromal phase, due to its impact on physical and mental health outcomes for those who go on to develop psychosis (Badcock et al., 2020; Lim et al., 2018; Narita et al., 2020). In addition, loneliness may mediate between factors, such as childhood abuse and intimate partner violence, and psychosis symptom development and distress (Boyda et al., 2015; Michalska da Rocha et al., 2018; Steenkamp et al., 2022). Loneliness has also been suggested to mediate between social functioning and health-related quality of life for those with psychosis (Nevarez-Flores, 2022). Understanding the role of loneliness as a potential mediator, and in relation to prodromal experiences is therefore important.

Increased loneliness has also been associated with poorer social functioning for those with psychosis (Badcock et al., 2015), and poorer social functioning has been associated with increased experiences of loneliness for people with psychosis and for those experiencing prodromal symptoms (Riggio & Kwong, 2009; Chrostek et al., 2016; Leathem et al., 2021). Symptoms of psychosis may contribute towards loneliness (Lim et al., 2018; Badcock et al., 2020), with increases in paranoia found to increase experiences of loneliness within students (Riggio & Kwong, 2009) and PLEs leading to increased experiences of loneliness (Leathem et al., 2021). However, these findings are not consistent, and it is argued that social issues precede symptom development in a unidirectional model (Gayer-Anderson & Morgan, 2013; Tan et al., 2021). Despite the suggested relationships between these factors, there is a lack of research determining the nature and directionality of the relationships between social functioning, loneliness, and prodromal experiences within a non-clinical population (Robustelli et al., 2017; Leathem et al., 2021). Understanding how social functioning and loneliness interact with prodromal symptoms and distress, could contribute towards the

development of preventative strategies to reduce the risk of psychosis onset (Devoe et al., 2019; Häfner, 2000; Narita et al., 2020; Lincoln et al., 2021).

Theories of social cognition could explain the potential relationships between loneliness, social functioning and prodromal symptoms of psychosis. Research suggests that the processing of social cues for those with psychosis is impaired (Brekke, Kay, Lee, & Green, 2005). Individuals with psychosis may have difficulties perceiving social interactions and difficulties with theory of mind, such as problems understanding the differing mental states of others (Healey et al., 2013; Lee, Hong, Shin, & Kwon, 2015; van Donkersgoed et al., 2015). This can lead to a reduced quality and quantity of interactions with others (Harvey, 2009) and limited social networks (Patterson et al., 1997). Understandably, the disruption to relationships with others and increased risk of social isolation could affect the ability to feel connected to others, increasing the likelihood of experiencing loneliness (Leathem et al., 2021; Okruszek et al., 2024). Poor social cognition has also been linked to poor social functioning, which is a known risk factor for psychosis (Gee & Cannon, 2011; Healey et al., 2016). The present study therefore aims to examine the relationships between social functioning, loneliness and prodromal symptoms and distress within a non-clinical sample using a longitudinal design with three timepoints: Time 1 (baseline), Time 2 (3-4 months), Time 3 (6-8 months). Based on previous findings, it was hypothesised that:

1) Higher reported prodromal symptoms and distress will be associated with lower levels of social functioning and higher levels of loneliness.
2) Loneliness reported at Time 2 will mediate the effect of social functioning at Time 1 on prodromal symptoms at Time 3.
3) Loneliness reported at Time 2 will mediate the effect of social functioning at Time 1 on prodromal symptom-related distress at Time 3.

2.3 Method

2.3.1 Design

A longitudinal design was used, following up a non-clinical sample at three time points over 6-8 months: Time 1 (baseline), Time 2 (3-4 months), Time 3 (6-8 months). The variables of interest included social functioning (IV), loneliness (IV/mediator), prodromal symptoms of psychosis (DV) and symptom related distress (DV). A priori power was calculated using G*Power 3.1 (Faul et al., 2009), a medium effect size was chosen based on previous research (Richardson et al., 2018). For bivariate Pearson's correlations using a medium effect size with an alpha value of .05 and power of .80, a total of 84 participants were required for the study. The required sample size for mediation was determined as 110 for a medium effect size and power of .80, based on literature on suggested mediation sample sizes (Sim et al., 2022)

2.3.2 Participants

The study data was used from an existing study comprising of 681 participants who met the study inclusion criteria (Richardson et al., 2015; Table 2). Inclusion criteria were: adult aged 18+, first-year British undergraduate students, commencing their degrees in 2011 (cohort 1) or 2012 (cohort 2), recruited through student unions based at UK universities. Exlcusion criteria were: International students (as the original study focused on tuition fee increases for British students), aged under 18, not enrolled in a UK university.

Table 2.

Inclusion and exclusion criteria (Richardson et al., 2015)

Inclusion Criteria	Exclusion Criteria
Adults over 18 years old	Under 18 years old
Enrolled at a university in the UK	Not enrolled in a UK university

First year student starting university in 2011 or 2012	Not commencing degree in 2011 or 2012
British and eligible for British tuition fee status	International students

A total of 276 participants were included in the present study, 276 completed Time 1 (baseline), 228 completed Time 2, and 216 completed Time 3. In total, 163 participants completed all three time points. Only participants that had completed all three measures for at least two time points were included, hence the sample size is smaller than the original study.

2.3.3 Measures

2.3.3.1 Demographic Questionnaire

A demographic questionnaire (Appendix C) was used to capture information relating to the participant's individual characteristics, including age, gender identity, ethnicity, disability and living situation.

2.3.3.2 The Prodromal Questionnaire-Brief Version (PQ-B; Loewy & Cannon, 2010)

This is a 21-item measure of psychosis risk (Appendix D). Items (21) assessing prodromal symptoms are answered as "yes/no", e.g., "do you feel that other people are watching you or talking about you?". The total prodromal symptom score is calculated from the sum of all answers, where "yes" = 1 and "no" = 0, yielding a total possible score of 0-21. Participants also rate how distressing each of these 21 experiences are using "strongly disagree, disagree, neutral, agree, strongly agree,", with values assigned from 1 to 5 respectively. The value of 0 is entered for distress items where there are no reported symptoms. A total distress score is calculated by the sum of all the distress ratings (range 0-105). This measure has good reliability for prodromal symptoms ($\alpha = .86$; Williams et al., 2022) and distress ($\alpha = .89$; Williams et al., 2022) and has been found to have concurrent

validity with the Structured Interview for Prodromal Syndromes (SIPS; Miller et al., 2003; Loewy et al., 2011). Reliability for the study sample was good for positive symptoms (Time 1, α = .81; Time 2, α = 81.; Time 3, α = .82) and distress (Time 1, α = .85; Time 2, α = 84.; Time 3, α = .85).

2.3.3.3 RAND 36-Item Health Survey (RAND36; Ware & Sherbourne, 1992)

This measure consists of subscales for different health concepts. This study used the social functioning subscale only (RAND36-SF), which consists of two items ('During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbours, or and groups?' and 'During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities [like visiting with friends, relatives, etc.]?') which participants rate on a Likert scale from 1 to 5, and each score is recoded to values of: 0, 25, 50, 75, 100 (Appendix E). The average score for both questions is then calculated. Scores range from 0 - 100, where a lower score indicates the presence of limitations in social functioning. This subscale has been found to have good reliability (α = .85; Ware & Sherbourne, 1992). The social functioning subscale also significantly correlated with other measures of social functioning, such as the COOP/WONCA charts (van Weel et al., 1995) which include a questionnaire of social activities (.80), demonstrating construct validity. Reliability for the study sample was good (Time 1, α = .86; Time 2, α = 87.; Time 3, α = .83).

2.3.3.4 UCLA Three Item Loneliness Scale (Hughes et al., 2004)

This is a three-item scale, which includes statements measuring experiences of loneliness ('How often do you feel that you lack companionship?', 'How often do you feel left out?', 'How often do you feel isolated from others?') and is designed for large surveys (Appendix F). Items are rated on a Likert scale from 1 to 3. This measure has been found to have acceptable reliability (α = .77; Lin et al., 2022). This scale also has a high correlation

(.82) with the longer 20 item UCLA Loneliness Scale (Russell, Peplau & Cutrona, 1980). Reliability for the study sample was good (Time 1, α = .86; Time 2, α = 84.; Time 3, α = .84).

2.3.4 Procedure

The study was approved by the University of Southampton Ethics and Research Governance Board (ERGO Ethics ID: 79715) on 06/02/2023 (see Appendix G). Invitations to take part in the original study (Richardson et al., 2015) were emailed to every university student union in the UK. Student unions were invited to forward the study details onto undergraduate students via emails, websites and/or social media. The study was advertised as a "Student Mental Health Survey," looking at factors relating to mental health in students. Informed consent was gained prior to taking part (Appendix H), with optional entry to a lottery to win vouchers after taking part. Participants were invited via an email link to complete online surveys at each time point. Participants who did not complete multiple time points were excluded from the original study data. Of the 113 universities were contacted, 46 advertised to the 2011 cohort and 44 advertised to the 2012 cohort. It was not known how many students saw the advert and therefore a response rate was not calculated.

2.3.4.1 Time points

The original study recruited two cohorts of first-year undergraduate students and collected data across four time points. The current study analysed data starting from the second time point in the original study, due to the PQ-B being introduced at this point. Data was collected between June 2012 and January 2014 as follows:

- Time Point 1: August – September 2012 (cohort 1), February 2013 (cohort 2)
- Time Point 2: November – December 2012 (cohort 1), May – July 2013 (cohort 2)
- Time Point 3: February 2013 (cohort 1), November 2013 – January 2014 (cohort 2)

2.3.5 Data Analysis Plan

Prior to analysis, data were screened for missing values, outliers, or errors in inputting. Analyses were performed using SPSS (Version 29; IBM Corporation, 2023) and statistical significance was set at $p = 0.05$. Total scores for social functioning, loneliness, prodromal symptoms, and symptom-related distress, formed continuous scales which were used for the analyses. Where any participants had completed at least 50% of the items for the measure, missing values were substituted with a mode (Richardson et al., 2015).

Preliminary checks were conducted for suitability for bivariate correlations and mediation (Field, 2017). Q-Q plots indicated the assumptions of linearity and homoscedasticity were met. There were no collinearity problems observed. Normal distribution was assessed using Kolmogorov-Smirnov and Shapiro-Wilkes tests, alongside visual inspection of histograms. Variables with skewness or kurtosis outside of -2/+2 were considered to be outside of a normal distribution. The PQ-B distress measure had high kurtosis (4.17), although skewness was within the normal range (1.28). The PQ-B distress measure was kept as a continuous variable as it was required as a dependent variable and bootstrapping was applied to mediation analyses. The remaining variables were normally distributed. Boxplots was screened for outliers (i.e., three standard deviations from the means), with a plan to adjust if required to the next highest score plus one (Field, 2017). There were no extreme outliers within the data.

Independent t-tests were used to explore any baseline differences for gender (male, female) and ethnicity (White, non-White) for all measures, with an aim to control for these in mediation analyses if statistically significant differences were found. Bivariate Pearson's correlations were used to examine the relationships between social functioning, loneliness, prodromal symptoms, and symptom-related distress.

PROCESS Model 4 (Version 4.2; Hayes, 2022) was used to test the following:

- Whether loneliness (Time 2) mediated the effect of social functioning (Time 1) on prodromal symptoms (Time 3). Prodromal symptoms at Time 1 were included in the model as a covariate.
- Whether loneliness (Time 2) mediated the effect of social functioning (Time 1) on symptom-related distress (Time 3). Symptom-related distress at Time 1 was included in the model as a covariate.

The decision was made not to impute missing data for each time point, to increase sample size for mediation, due to the data having already been manipulated for the original study, e.g., substitution of missing data for the mode. Imputation of missing data points may inflate the effects of already substituted values. The reverse models were also tested to address directionality of effects (i.e., prodromal symptoms or distress predicting social functioning), again controlling for baseline (Time 1) measures. Only participants that had completed all three time points were included in the mediation analyses (n = 163). Indirect effects were inferred using percentile bootstrapping, producing 95% confidence intervals (CI) for each indirect effect. Mediation occurred when the CIs for indirect effect do not straddle zero (Hayes, 2018).

2.4 Results

2.4.1 Participant Characteristics

Demographic characteristics for the sample are shown in Table 3. The sample was predominantly female (79.3%, n = 219), and White British or White other (90.9%, n = 251). The age of participants ranged from 18-59 years (M = 21.01, SD = 5.36).

Table 3.

Participant characteristics

Characteristic	Total / Time 1	Time 2	Time 3

N	276	228	216
Age (years)			
Mean (SD)	20.57 (5.37)	21.64 (5.42)	21.01 (5.36)
Range	18-58	18-59	17-59
Gender			
Female (Total %)	219 (79.3%)	177	174
Male (Total %)	56 (20.3%)	49	41
Did not state	1 (0.4%)	1	1
Ethnicity			
Asian/Asian British (Total %)	4 (1.4%)	4	4
Black/Black British (Total %)	3 (1.1%)	1	3
Mixed (Total %)	13 (4.7%)	7	11
Other (Total %)	2 (0.7%)	1	2
White British/ White other (Total %)	251 (90.9%)	211	194
Did not state (Total %)	3 (1.1%)	3	2

2.4.2 Main Findings

T-tests for Time 1 (baseline) differences based on gender were not statistically significant: PQ-B prodromal symptoms, $t(273) = 1.63$, $p = .06$; PQ-B symptom-related distress, $t(273) = .12$, $p = .45$; social functioning, $t(273) = 1.43$, $p = .08$; loneliness, $t(273) = 1.41$, $p = .08$. T-tests for baseline (Time 1) differences based on ethnicity were also not statistically significant: PQ-B prodromal symptoms, $t(271) = .41$, $p = .34$; PQ-B symptom-related distress, $t(271) = .13$, $p = .45$; social functioning, $t(271) = -1.44$, $p = .08$; loneliness, $t(271) = -.13$, $p = .45$. Gender and ethnicity were therefore not added as covariates within the mediation analyses.

2.4.2.1 Hypothesis 1: Higher reported prodromal symptoms and distress on the PQ-B will be associated with lower levels of social functioning and higher levels of loneliness.

Bivariate Pearson's correlations are shown in Table 4. Social functioning (M = 76.98, SD = 25.53) was negatively significantly correlated with both prodromal symptoms (M = 3.77, SD = 3.52), $r(274) = -.42$, $p < .001$, 95% CI [-.51, -.31]., and distress (M = 11.52, SD = 12.97), $r(274) = -.52$, $p < .001$, 95% CI [-.60, -.43]. This suggests that individuals with lower social functioning reported higher prodromal symptoms and higher symptom-related distress.

Loneliness (M = 5.67, SD = 1.95) was also positively significantly correlated with both prodromal symptoms, $r(274) = .40$, $p < .001$, 95% CI [.29, .50], and distress, $r(274) = .43$, $p < .001$, 95% CI [.33, .53]. This suggests that individuals experiencing higher loneliness reported higher prodromal symptoms and higher levels of distress.

Table 4.

Bivariate Pearson's correlations matrix at baseline (Time 1).

	Mean (SD)	1	2	3	4
RAND36 Social Functioning	76.98 (25.53)	-			
UCLA Loneliness	5.69 (1.95)	-.521**	-		
PQB Symptoms	3.77 (3.52)	-.417**	.399**	-	
PQB Distress	11.52 (12.97)	-.522**	.433**	.936**	-

** $p < 0.001$

2.4.2.2 Hypothesis 2: Loneliness reported at Time 2 will mediate the effect of social functioning at Time 1 on prodromal symptoms (PQ-B) at Time 3.

The first analysis tested whether loneliness mediated the effect of social functioning on prodromal symptoms, whilst controlling for baseline (Time 1) prodromal symptoms as a covariate (see Figure 2, a). The direct effect of social functioning on prodromal symptoms

was negative and non-significant (β = -.022, *p* = .719, *SE* = .008, 95% CI [.719, -.019]). The total effect of social functioning on prodromal symptoms was also negative and non-significant (β = -.062, *p* = .313, *SE* = .008, 95% CI [.313, -.023]). There was a significant indirect effect, suggesting that social functioning predicted prodromal symptoms via loneliness (β = -.039, bootstrapped *SE* = .020, bootstrapped 95% CI [-.082, -.005]). Controlling for baseline (Time 1) prodromal symptoms, lower social functioning predicted higher loneliness, and higher loneliness predicted higher prodromal symptoms.

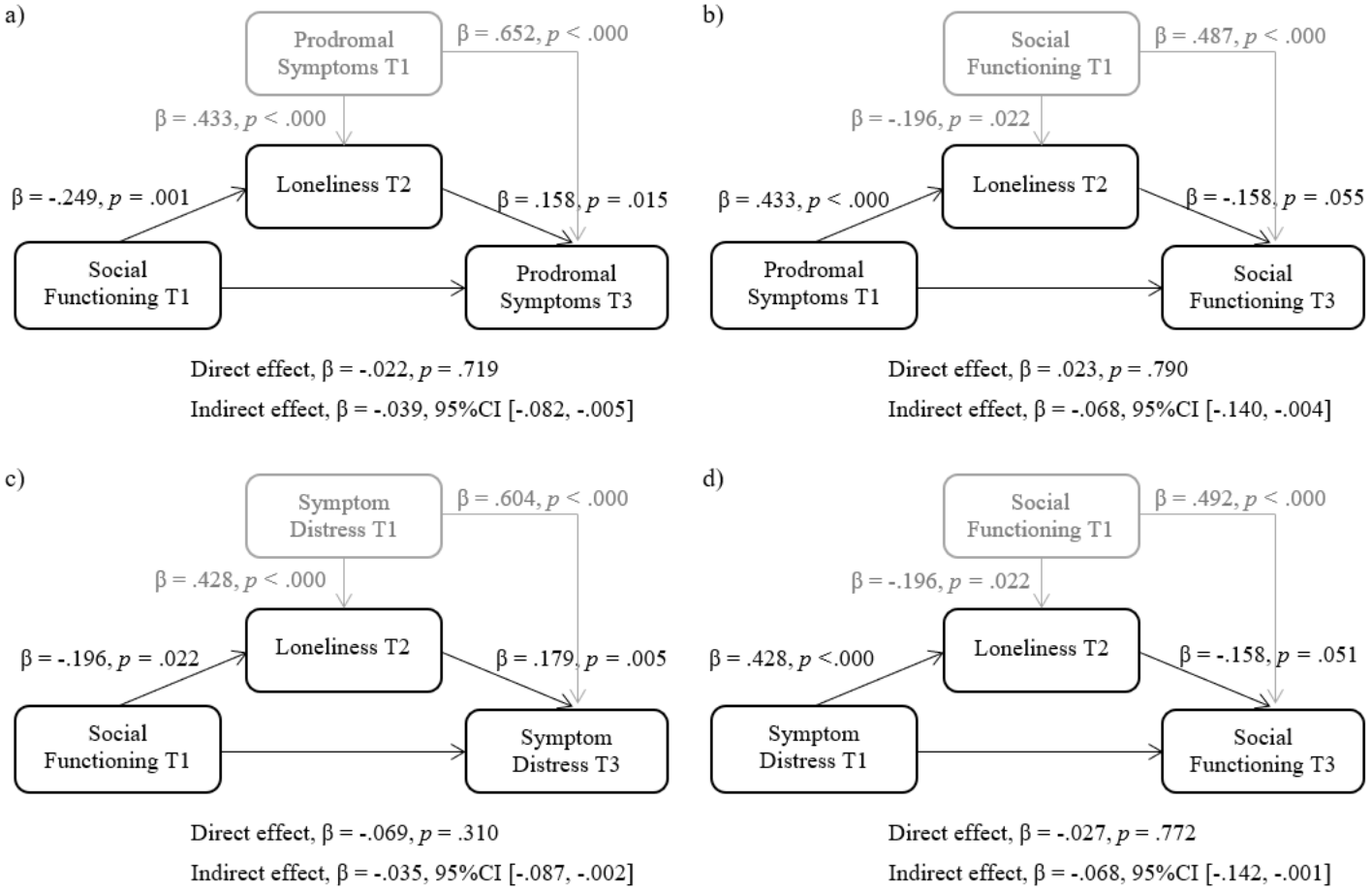
The second analysis reversed the model, testing whether loneliness mediated the effect of prodromal symptoms on social functioning, whilst controlling for baseline (Time 1) social functioning as a covariate (see Figure 2, b). The direct effect of prodromal symptoms on social functioning was positive and non-significant (β = .023, *p* = .790, *SE* = .616, 95% CI [-1.051, 1.380]). The total effect of prodromal symptoms on social functioning was negative and non-significant (β = -.046, *p* = .554, *SE* = .564, 95% CI [-1.447, .779]). The indirect effect for the reversed model was significant, suggesting that prodromal symptoms predicted social functioning via loneliness (β = -.068, bootstrapped *SE* = .035, bootstrapped 95% CI [-.140, -.004]). Controlling for baseline (Time 1) social functioning, higher prodromal symptoms predicted higher loneliness, and higher loneliness predicted lower social functioning.

2.4.2.3 Hypothesis 3: Loneliness reported at Time 2 will mediate the effect of social functioning at Time 1 on symptom-related distress (PQ-B) at Time 3.

The third analysis tested whether loneliness mediated the effect of social functioning on symptom-related distress, whilst controlling for baseline (Time 1) distress as a covariate (see Figure 2, c). The direct effect of social functioning on symptom-related distress was negative and non-significant (β = -.069, *p* = .310, *SE* = .031, 95% CI [-.092, .029]). The total effect of social functioning on symptom-related distress was also negative and non-significant (β = -.104, *p* = .129, *SE* = .031, 95% CI [-.108, .014]). There was a significant indirect effect, after controlling for the effect of baseline (Time 1) symptom-related distress. Social functioning predicted symptom-related distress via loneliness (β = -.035, bootstrapped *SE*

Figure 2.

Path models of relationships between social functioning, loneliness, prodromal symptoms and symptom distress, controlling for baseline (Time 1) symptoms. Path coefficients are standardised regression coefficients.

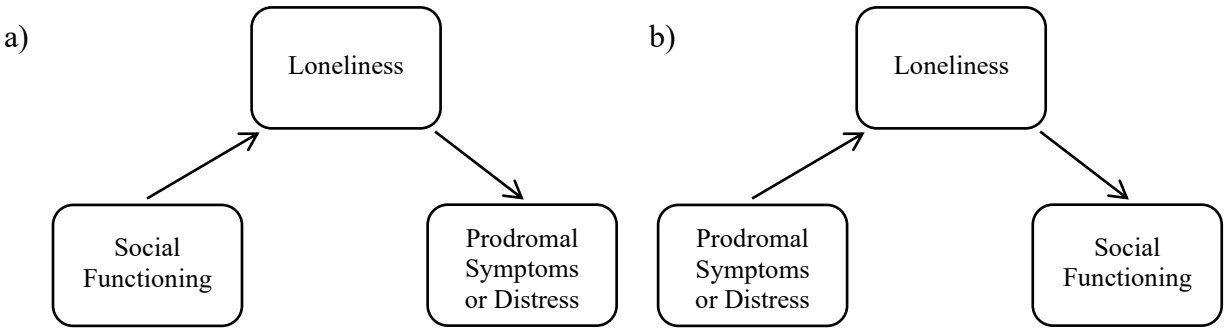


= .022, bootstrapped 95% CI [-.087, -.002]). Controlling for baseline (Time 1) symptom-related distress, lower social functioning predicted higher loneliness, and higher loneliness predicted higher symptom-related distress.

The fourth analysis reversed the model, testing whether loneliness mediated the effect of symptom-related distress on social functioning, whilst controlling for baseline (Time 1) social functioning (see Figure 2, d). The direct effect of symptom-related distress on social functioning was positive and non-significant (β = .027, *p* = .772, *SE* = .031, 95% CI [-.318, .428]). The total effect of symptom-related distress on social functioning was negative and non-significant (β = -.041, *p* = .639, *SE* = .031, 95% CI [-.433, .267]). The indirect effect for the reversed model was significant, suggesting that symptom-related distress predicted social functioning via loneliness (β = -.068, bootstrapped *SE* = .036, bootstrapped 95% CI [-.142, -.001]). Controlling for baseline (Time 1) social functioning, higher symptom-related distress predicted higher loneliness, and higher loneliness predicted lower social functioning.

Figure 3.

Final models of relationships between social functioning, loneliness, prodromal symptoms and symptom distress.



2.5 Discussion

We report the findings from the first longitudinal study to test mediation models examining loneliness as a mediator of the relationship between social functioning and prodromal symptoms and distress in a non-clinical population.

2.5.1 Main Findings

Social functioning was negatively associated with prodromal symptoms and symptom-related distress on the PQ-B, suggesting that as social functioning decreases, prodromal symptoms, and distress increases. Likewise, loneliness was positively associated with prodromal symptoms and symptom-related distress, suggesting that those reporting higher loneliness experience higher prodromal symptoms and distress. Collectively, these findings support existing research, that social functioning is lower for individuals experiencing prodromal symptoms (Robustelli et al., 2017), and loneliness is associated with prodromal symptoms (Robustelli et al., 2017; Mäki et al., 2014; Sündermann et al., 2014; Michalska da Rocha et al., 2018; Raposo de Almeida et al., 2024). We add to the evidence by showing, for the first time, that lower social functioning, and higher levels of loneliness, are associated with higher prodromal distress. In line with previous studies, these findings suggest that social functioning impairments may present prior to diagnosis, preceding or alongside prodromal symptoms (Addington et al., 2008; Cornblatt et al., 2012).

We also tested a series of mediation models to examine whether loneliness mediated the effect of social functioning on prodromal symptoms and distress. Whilst controlling for baseline prodromal symptoms, there was a significant indirect effect of social functioning on prodromal symptoms, which was mediated by loneliness. This suggests that lower social functioning leads to higher loneliness, and higher loneliness leads to higher prodromal symptoms. In addition to this, there was a significant indirect effect when the model was reversed, suggesting that higher prodromal symptoms leads to lower social functioning via loneliness. These findings both support research suggesting that prodromal symptoms of psychosis can increase loneliness (Riggio & Kwong, 2009; Leathem et al., 2021) and provide evidence contrary to the suggested unidirectional relationship between social factors and prodromal symptoms (Gayer-Anderson & Morgan, 2013; Tan et al., 2021). These results provide evidence that loneliness has a mediating role in exacerbating prodromal symptoms, similar to existing studies (Boyda et al., 2015; Michalska da Rocha et al., 2018). This may be

explained by theoretical models that propose that social deficits can reinforce symptoms in a maintaining cycle (Garety et al., 2001; Freeman & Garety, 2006; Freeman et al., 2007).

Finally, whilst controlling for baseline distress, there was a significant indirect effect of social functioning on symptom-related distress on the PQ-B, with loneliness as a mediator. This suggests that lower social functioning leads to higher loneliness, and higher loneliness leads to higher distress. The reversed model also had a significant indirect effect, suggesting that higher distress leads to higher loneliness, and higher loneliness leads to lower social functioning. To our knowledge, this is the first study to demonstrate the relationship between social functioning, loneliness, and prodromal symptom-related distress. The bidirectional nature of the model may be explained by existing theories which propose that distress increases social withdrawal, limiting opportunities to develop social skills and challenge positive symptoms (e.g., beliefs), which leads to greater levels of distress (Freeman & Garety, 2006; Freeman et al., 2007).

However, these results should be interpreted cautiously as they may be limited by the measures selected for the original study. In particular, the wording of the social functioning measure could have implications for the results. The questions related to social functioning ask participants to rate their experiences based on their physical and emotional health. This may have an impact on the directionality of social functioning on symptoms and distress, due to the ratings for social functioning being based upon physical and emotional issues. These were not controlled for within the present study. Therefore, it is possible that social functioning difficulties could be affected by other factors, e.g., low mood, physical health limitations. Additionally, the wording suggests that ratings are in response to presenting issues, rather than pre dating them.

Considering the mediation models (Figure 3), it could be argued that impairments in social functioning leading to increased loneliness and therefore increased prodromal symptoms or distress makes more theoretical sense (Figure 3, a). Evidence suggests that social changes take place before experiencing PLEs (Cornblatt et al., 2003; Phillips et al.,

2005; Schultze-Lutter et al., 2010), and that loneliness mediates between risk factors and psychosis development (Boyda et al., 2015; Michalska da Rocha et al., 2018; Steenkamp et al., 2022). Theories on psychosis symptom development may explain the reversed models as part of a maintaining cycle, as prodromal symptoms and distress can lead to increased loneliness and less opportunities to develop social skills, limiting opportunities for connections and support (Garety et al., 2001; Freeman & Garety, 2006; Freeman et al., 2007; Gayer-Anderson & Morgan, 2013).

2.5.2 Clinical Implications

These findings suggest that social functioning and loneliness might be important intervention targets, for preventative strategies for psychosis. Targeting social functioning might reduce experiences of loneliness and enable a person to manage their experiences of prodrome symptoms more effectively and therefore reduce symptom-related distress (Garety et al., 2001; Freeman & Garety, 2006; Freeman, 2007; Carrión et al., 2021). The findings provide additional evidence that reduced social functioning and increased loneliness present alongside prodrome symptoms (Addington et al., 2019; Devoe et al., 2019; Carrión et al., 2021) and within a non-clinical population. Therefore public health interventions for psychosis should consider addressing these social determinants earlier on (Fusar-Poli, 2021). For example, interventions could involve developing social functioning skills and tackling experienced loneliness within schools, colleges, and universities. Evidence suggests that community based social interventions can reduce loneliness (McNamara et al., 2021) and, within the UK, social prescribing has been promoted and adapted to include online formats for accessibility (NHS England, 2019). Peer support groups can be an effective intervention for loneliness (Richard et al., 2022), and for the purposes of a student population could include establishing structured social activities within education settings to improve social connectedness (McLaughlin & Sillence, 2018; Ellard et al., 2022).

2.5.3 Limitations and Future Research

There are a number of limitations of the study that warrant consideration. Although a longitudinal design was used collecting data at three time points over an 8 month study period, this study was not able to determine whether these relationships were maintained longer-term. The PQ-B distress measure was also outside of normal distribution, and therefore did not meet some of the assumptions for analysis and could have limited the results. In addition, the measure of social functioning could be critiqued for its brevity and wording, which encourages participants to consider their social functioning in relation to physical and emotional issues and lacks elaboration on the different components of social functioning. This may have affected the association with prodromal symptoms and distress, as factors related to physical health were not controlled for within this study and important factors relating to social functioning may have been overlooked. Future research should consider the use of more detailed measures, to capture the different facets of social functioning. The study may also be limited by the small sample size and therefore larger scale studies may be required to determine if the findings are replicated.

The sample for this study also mostly comprised of White British, female, young adults, from a high-income country, which could limit generalisability to males and may not generalise cross-culturally and for low or middle income countries. The study also recruited from a student population which is not representative of the general population. Furthermore, as the original study was advertised as a mental health survey, it may have attracted participants who were more likely to have poor mental health. Future research might usefully determine whether these findings are replicated within other populations, including cross-culturally, and across a longer period of time. Future studies should also examine whether these findings are replicated for individuals at ultra-high risk of psychosis. In addition, as the average age of psychosis onset may be 20.5 years (Solmi et al., 2022), future studies focusing

on prevention might also explore whether these findings hold in younger adolescent populations.

Finally, the lack of patient and public involvement (PPI) is also a limitation of this study. Due to using secondary data analysis the study was limited in its ability to involve PPI within the methodology. However, PPI involvement would have been beneficial for a meaningful interpretation of the findings and developing a lay summary. Future research should include PPI in the development of the research question and selection of measures, for example selecting a measure of social functioning.

2.5.4 Conclusion

This is the first study to show that loneliness acts as a mediator between social functioning and prodromal symptoms and symptom-related distress within a non-clinical population. The findings also suggest that loneliness mediated between prodromal symptoms, symptom-related distress, and social functioning in a reversed model. Public health interventions should target increasing social functioning skills, with an aim to reduce loneliness and prodromal symptoms and symptom-related distress. Future longitudinal studies are needed to determine whether these findings hold within ultra-high risk and younger populations, and whether the findings generalise cross-culturally.

2.6 Author Contributions

Access to dataset (TR), study design and protocol (TR, LM, LE); data analysis plan (LM, LE, TR); data analysis (LM, LE); writing original draft (LM); editing (LM, LE, TR); supervision (LE, TR).

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2.8 Data Availability Statement

The dataset used is available from TR on reasonable request.

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Appendix A PRISMA 2020 Checklist

Used in 'Chapter 1 - Exposure to Green Spaces and Schizophrenia: A Systematic Review'. Submitted as supplementary material.

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	P 13-14, 16
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	P 13
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	P 15-16
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	P 16
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	P 16-17
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	P 17 Figure 1
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	P 17
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	P 17
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	P 18

Section and Topic	Item #	Checklist item	Location where item is reported
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	P 20-22
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	P 18, 20-22
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	P 17
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	P 22, 30-31
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Figure 1
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	N/A
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Table 1
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	P 18
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	N/A
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	P 17-18
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	P 17-18
RESULTS			

Section and Topic	Item #	Checklist item	Location where item is reported
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	P 18, Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Figure 1
Study characteristics	17	Cite each included study and present its characteristics.	P 18, 20-22 Table 1
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Table 1
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Table 1
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	P 22, 30-31
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	N/A
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	N/A
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Table 1
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	P 22, 30-31
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	P 33-34
	23b	Discuss any limitations of the evidence included in the review.	P 34-35
	23c	Discuss any limitations of the review processes used.	P 35

Section and Topic	Item #	Checklist item	Location where item is reported
	23d	Discuss implications of the results for practice, policy, and future research.	P 34-36
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	P 16
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	P 16
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	On the title page of journal submission
Competing interests	26	Declare any competing interests of review authors.	On the title page of journal submission
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	P 36

Appendix B Quality Assessment Tool

Used in 'Chapter 1 - Exposure to Green Spaces and Schizophrenia: A Systematic Review'. A quality assessment tool for evaluating quantitative research.

QUALITY ASSESSMENT TOOL FOR QUANTITATIVE STUDIES

EPHPP
Effective Public Health Practice Project

COMPONENT RATINGS

A) SELECTION BIAS

(Q1) Are the individuals selected to participate in the study likely to be representative of the target population?

1 Very likely
2 Somewhat likely
3 Not likely
4 Can't tell

(Q2) What percentage of selected individuals agreed to participate?

1 80 - 100% agreement
2 60 – 79% agreement
3 less than 60% agreement
4 Not applicable
5 Can't tell

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

B) STUDY DESIGN

Indicate the study design

1 Randomized controlled trial
2 Controlled clinical trial
3 Cohort analytic (two group pre + post)
4 Case-control
5 Cohort (one group pre + post (before and after))
6 Interrupted time series
7 Other specify _____
8 Can't tell

Was the study described as randomized? If NO, go to Component C.

No Yes

If Yes, was the method of randomization described? (See dictionary)

No Yes

If Yes, was the method appropriate? (See dictionary)

No Yes

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

1

C) CONFOUNDERS

(Q1) Were there important differences between groups prior to the intervention?

1 Yes
2 No
3 Can't tell

The following are examples of confounders:

1 Race
2 Sex
3 Marital status/family
4 Age
5 SES (income or class)
6 Education
7 Health status
8 Pre-intervention score on outcome measure

(Q2) If yes, indicate the percentage of relevant confounders that were controlled (either in the design (e.g. stratification, matching) or analysis)?

1 80 – 100% (most)
2 60 – 79% (some)
3 Less than 60% (few or none)
4 Can't Tell

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

D) BLINDING

(Q1) Was (were) the outcome assessor(s) aware of the intervention or exposure status of participants?

1 Yes
2 No
3 Can't tell

(Q2) Were the study participants aware of the research question?

1 Yes
2 No
3 Can't tell

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

E) DATA COLLECTION METHODS

(Q1) Were data collection tools shown to be valid?

1 Yes
2 No
3 Can't tell

(Q2) Were data collection tools shown to be reliable?

1 Yes
2 No
3 Can't tell

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

F) WITHDRAWALS AND DROP-OUTS

(Q1) Were withdrawals and drop-outs reported in terms of numbers and/or reasons per group?

1 Yes
2 No
3 Can't tell
4 Not Applicable (i.e. one time surveys or interviews)

(Q2) Indicate the percentage of participants completing the study. (If the percentage differs by groups, record the lowest).

1 80 -100%
2 60 - 79%
3 less than 60%
4 Can't tell
5 Not Applicable (i.e. Retrospective case-control)

RATE THIS SECTION	STRONG	MODERATE	WEAK	
See dictionary	1	2	3	Not Applicable

G) INTERVENTION INTEGRITY

(Q1) What percentage of participants received the allocated intervention or exposure of interest?

1 80 -100%
2 60 - 79%
3 less than 60%
4 Can't tell

(Q2) Was the consistency of the intervention measured?

1 Yes
2 No
3 Can't tell

(Q3) Is it likely that subjects received an unintended intervention (contamination or co-intervention) that may influence the results?

4 Yes
5 No
6 Can't tell

H) ANALYSES

(Q1) Indicate the unit of allocation (circle one)

community organization/institution practice/office individual

(Q2) Indicate the unit of analysis (circle one)

community organization/institution practice/office individual

(Q3) Are the statistical methods appropriate for the study design?

1 Yes
2 No
3 Can't tell

(Q4) Is the analysis performed by intervention allocation status (i.e. intention to treat) rather than the actual intervention received?

1 Yes
2 No
3 Can't tell

GLOBAL RATING

COMPONENT RATINGS

Please transcribe the information from the gray boxes on pages 1-4 onto this page. See dictionary on how to rate this section.

A	**SELECTION BIAS**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
B	**STUDY DESIGN**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
C	**CONFOUNDERS**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
D	**BLINDING**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
E	**DATA COLLECTION METHOD**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
F	**WITHDRAWALS AND DROPOUTS**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	Not Applicable

GLOBAL RATING FOR THIS PAPER (circle one):

1	STRONG	(no WEAK ratings)
2	MODERATE	(one WEAK rating)
3	WEAK	(two or more WEAK ratings)

With both reviewers discussing the ratings:

Is there a discrepancy between the two reviewers with respect to the component (A-F) ratings?

No Yes

If yes, indicate the reason for the discrepancy

1	Oversight
2	Differences in interpretation of criteria
3	Differences in interpretation of study

Final decision of both reviewers (circle one):

1	**STRONG**
2	**MODERATE**
3	**WEAK**

Appendix C Demographic Questionnaire

Author Constructed Demographic Questionnaire (Richardson et al., 2015).

Used in 'Chapter 2 – Loneliness as a Mediator between Social Functioning and Prodromal Psychosis Symptoms Over Time'. Demographic questions for participants.

Demographics

1. Gender

Male [ ] 1

Female [ ] 2

2. Age _____

3. Ethnic Status

a) Black or Black British

- Caribbean
- African
- Any other Black background within (a)

b) White

- British
- Irish
- Any other White background

c) Asian or Asian British

- Indian
- Pakistani
- Bangladeshi
- Any other Asian background within (c)

d) Mixed

- White & Black Caribbean
- White & Black African
- White & Asian
- White & Hispanic
- Any other mixed background

e) Other ethnic groups

- Chinese
- Japanese
- Hispanic
- Any other ethnic group
- Do not state

7. Do you have a disability?

Yes [ ] 1

No [ ] 2

IF YES *Please give details* .....

8. Are you a mature student?

Yes [ ] 1

No [ ] 2

9. Where do you live during term time at the moment?

University Halls

Rented Flat/House with Other Students

At home with parents/guardian

Other

Appendix D Prodromal Questionnaire Brief

Used in 'Chapter 2 - Loneliness as a Mediator between Social Functioning and Prodromal Psychosis Symptoms Over Time'. A screening measure for symptoms indicating risk for psychosis.

Please indicate whether you have had the following thoughts, feelings and experiences **in the past month** by checking "yes" or "no" for each item. **Do not include experiences that occur only while under the influence of alcohol, drugs or medications that were not prescribed to you**. If you answer "YES" to an item, also indicate how distressing that experience has been for you.

1. Do familiar surroundings sometimes seem strange, confusing, threatening or unreal to you?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

2. Have you heard unusual sounds like banging, clicking, hissing, clapping or ringing in your ears?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

3. Do things that you see appear different from the way they usually do (brighter or duller, larger or smaller, or changed in some other way)?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

4. Have you had experiences with telepathy, psychic forces, or fortune telling?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

5. Have you felt that you are not in control of your own ideas or thoughts?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

6. Do you have difficulty getting your point across, because you ramble or go off the track a lot when you talk?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

7. Do you have strong feelings or beliefs about being unusually gifted or talented in some way?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

8. Do you feel that other people are watching you or talking about you?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

9. Do you sometimes get strange feelings on or just beneath your skin, like bugs crawling?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

10. Do you sometimes feel suddenly distracted by distant sounds that you are not normally aware of?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

11. Have you had the sense that some person or force is around you, although you couldn't see anyone?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

12. Do you worry at times that something may be wrong with your mind?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

13. Have you ever felt that you don't exist, the world does not exist, or that you are dead?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

14. Have you been confused at times whether something you experienced was real or imaginary?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

15. Do you hold beliefs that other people would find unusual or bizarre?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

16. Do you feel that parts of your body have changed in some way, or that parts of your body are working differently?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

17. Are your thoughts sometimes so strong that you can almost hear them?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

18. Do you find yourself feeling mistrustful or suspicious of other people?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

19. Have you seen unusual things like flashes, flames, blinding light, or geometric figures?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

20. Have you seen things that other people can't see or don't seem to see?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

21. Do people sometimes find it hard to understand what you are saying?

☐ **YES** ☐ **NO** ***If YES:*** When this happens, I feel frightened, concerned, or it causes problems for me:

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ Strongly agree

Scoring:

Total Score = Sum of all 21 items with No = 0, Yes = 1.

Distress Score= Sum of all 21 items with No = 0; Yes: strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, strongly agree = 5

Appendix E RAND-36 Health Survey

RAND Social Functioning Subscale

Used in 'Chapter 2 - Loneliness as a Mediator between Social Functioning and Prodromal Psychosis Symptoms Over Time'.

20. During the **past 4 weeks**, to what extent has your **physical health or emotional problems** interfered with your normal social activities with family, friends, neighbours, or and groups?

1 - Not at all	2 - Slightly	3 - Moderately	4 - Quite a bit	5 - Extremely
○	○	○	○	○

32. During the **past 4 weeks**, how much of the time has your **physical health or emotional problems** interfered with your social activities (like visiting with friends, relatives, etc.)?

1 – All of the time	2 – Most of the time	3 – Some of the time	4 – A little of the time	5 – None of the time
○	○	○	○	○

Table 1.

Subscales and item numbers

Scale	Number of items	After recoding per Table 1, average the following items
Physical functioning	10	3 4 5 6 7 8 9 10 11 12
Role limitations due to physical health	4	13 14 15 16
Role limitations due to emotional problems	3	17 18 19
Energy/fatigue	4	23 27 29 31
Emotional well-being	5	24 25 26 28 30
Social functioning	2	20 32
Pain	2	21 22
General health	5	1 33 34 35 36

Table 2.

Recoding items

Item numbers	Change original response category *	To recoded value of:
1, 2, 20, 22, 34, 36	1 →	100
	2 →	75
	3 →	50
	4 →	25
	5 →	0
3, 4, 5, 6, 7, 8, 9, 10, 11, 12	1 →	0
	2 →	50
	3 →	100
13, 14, 15, 16, 17, 18, 19	1 →	0
	2 →	100
21, 23, 26, 27, 30	1 →	100
	2 →	80
	3 →	60
	4 →	40
	5 →	20
	6 →	0
24, 25, 28, 29, 31	1 →	0
	2 →	20
	3 →	40
	4 →	60
	5 →	80
	6 →	100
32, 33, 35	1 →	0
	2 →	25
	3 →	50
	4 →	75
	5 →	100

Appendix F UCLA Three Item Loneliness Scale

UCLA 3-Item Loneliness Scale

Used in 'Chapter 2 - Loneliness as a Mediator between Social Functioning and Prodromal Psychosis Symptoms Over Time'.

1. How often do you feel that you lack companionship?		
1 – Hardly ever	2 – Some of the time	3 - Often
○	○	○
2. How often do you feel left out?		
1 – Hardly ever	2 – Some of the time	3 - Often
○	○	○
3. How often do you feel isolated from others?		
1 – Hardly ever	2 – Some of the time	3 - Often
○	○	○

The scores for each individual question can be added together to provide a possible range of scores from 3 to 9.

Appendix G Ethical Approval

Used in ‘Chapter 2 – Loneliness as a Mediator between Social Functioning and Prodromal Psychosis Symptoms Over Time’ .

Approved by Faculty Ethics Committee - ERGO II 79715

UNIVERSITY OF Southampton

ERGO II – Ethics and Research Governance Online https://www.ergo2.soton.ac.uk

Submission ID: 79715
Submission Title: The Relationship between loneliness and psychotic symptoms over time in a sample of British undergraduate students.
Submitter Name: Thomas Richardson

Your submission has now been approved by the Faculty Ethics Committee. You can begin your research unless you are still awaiting any other reviews or conditions of your approval.

Comments:

-

Click here to view the submission

TId: 23011_Email_to_submitter___Approval_from_Faculty_Ethics_committee__cat_B___C_ Id: 598004

T.H.Richardson@soton.ac.uk coordinator

Please do not reply to this message as it has been automatically generated by the system. This email address is not monitored.

Appendix H Consent Form

Used in 'Chapter 2 - Loneliness as a Mediator between Social Functioning and Prodromal Psychosis Symptoms Over Time'. As part of original study by Richardson et al. (2015).

UNIVERSITY OF Southampton

CONSENT FORM (*Version 4*)

Study title: Student Mental Health Survey

Researcher name: Thomas Richardson, Ron Roberts, Peter Elliott
Ethics number: 3491

Please tick the following boxes to show you agree to take part in the study. You need to tick **every box** in order to take part.

I have read and understood the information sheet and if I have any questions I have contacted the author (studentmentalhealthsurvey@gmail.com)	☐
I agree to take part in this research project and agree for my data to be used for the purpose of this study	☐
I understand my participation is voluntary and I may withdraw at any time without my legal rights being affected	☐
I understand that information collected about me during my participation in this study will be stored on a password protected computer and that this information will only be used for the purpose of this study. All information collected is confidential.	☐

|

[27/07/12] [Version 4]

Appendix I Chapter 1 Author Guidelines

Guidelines followed for 'Chapter 1 - Exposure to Green Spaces and Schizophrenia: A Systematic Review', from Psychological Medicine at:

https://www.cambridge.org/core/journals/psychological-medicine/information/author-instructions

Preparing your materials – Psychological Medicine, Cambridge University Press

Please see the below table for the types of papers accepted:

Article Type	Usual Max Word count*	Abstract	References	Tables/figures**	Supplementary material online only	Eligible for Transformative Agreement Coverage
Original article	4500	250 words, structured, using subheadings Background, Methods, Results, Conclusions	APA style	Usually up to 5 total	Yes	Yes
Review article	4500	250 words, not structured	APA style	Usually up to 5 total	Yes	Yes

Generally papers should not have text more than 4500 words in length (excluding abstract, tables/figures and references) and should not have more than a combined total of 5 tables and/or figures. Papers shorter than these limits are encouraged. For papers of unusual importance the editors may waive these requirements. Articles require a structured abstract of no more than 250 words including the headings: Background; Methods; Results; Conclusions. Review Articles require an unstructured abstract of no more than 250 words. The name of an author to whom correspondence should be sent must be indicated and a full postal address given in the footnote. Any acknowledgements should be placed at the end of the text (before the References section).

References

The guidelines set forth in the *Publication Manual of the American Psychological Association* (6th ed.) should be used in the text and a complete list of References cited given at the end of the article.

The References section should be in alphabetical order.

No retrieval date is needed.

Figures and tables

Only essential figures and tables should be included and should be provided in black and white except in exceptional circumstances, eg PET scan images etc. If you request colour figures in the printed version, you will be contacted by CCC-Rightslink who are acting on our behalf to collect Author Charges. Please follow their instructions in order to avoid any delay in the publication of your article. Further tables, figures, photographs and appendices, may be included with the online version on the journal website.

Please ensure that your figures are saved at final publication size (please see the latest issue of the journal for column widths) and are in our recommended file formats. Following these guidelines will result in high quality images being reproduced in both the print and the online versions of the journal.

All graphs and diagrams should be referred to as figures and should be numbered consecutively in Arabic numerals. Captions for figures should be typed double-spaced on separate sheets. Tables should be numbered consecutively in the text in Arabic numerals and each typed on a separate sheet after the References section. Titles should be typed above the table.

Required Statements

Acknowledgements

You may acknowledge individuals or organisations that provided advice, support (non-financial). Formal financial support and funding should be listed in the following section.

Financial support

Authors must include a Funding Statement in their manuscript. Within this statement please provide details of the sources of financial support for all authors, including grant numbers, for example: “Funding Statement: This work was supported by the Medical Research Council (grant number XXXXXXX)”. Grants held by different authors should be identified as belonging to individual authors by the authors’ initials, for example: “Funding Statement: This work was supported by the Wellcome Trust (AB, grant numbers XXXX, YYYY), (CD, grant number ZZZZ); the Natural Environment Research Council (EF, grant number FFFF); and the National Institutes of Health (AB, grant number GGGG), (EF, grant number HHHH).” Where no specific funding has been provided for research, you should include the following statement:

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Author 3 has received grants from company D." If no competing interests exist, the declaration should state "Competing interests: The author(s) declare none".

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Appendix J Chapter 2 Author Guidelines

Guidelines followed for 'Chapter 2: Loneliness as a Mediator between Social Functioning and Prodromal Psychosis Symptoms Over Time', from Mental Health and Prevention at:

https://www.sciencedirect.com/journal/mental-health-and-prevention/publish/guide-for-authors

Types of article

- Full-Length Research Papers (up to 5000 words, excluding references and up to 6 tables/figures).

Article structure

Subdivision - numbered sections

Divide your article into clearly defined and numbered sections. Subsections should be numbered 1.1 (then 1.1.1, 1.1.2, ...), 1.2, etc. (the abstract is not included in section numbering). Use this numbering also for internal cross-referencing: do not just refer to 'the text'. Any subsection may be given a brief heading. Each heading should appear on its own separate line.

Introduction

State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

Material and methods

Provide sufficient details to allow the work to be reproduced by an independent researcher. Methods that are already published should be summarized, and indicated by a reference. If quoting directly from a previously published method, use quotation marks and also cite the source. Any modifications to existing methods should also be described.

Results

Results should be clear and concise.

Discussion

This should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is also appropriate.

Conclusions

The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a Discussion or Results and Discussion section.

Appendices

If there is more than one appendix, they should be identified as A, B, etc. Formulae and equations in appendices should be given separate numbering: Eq. (A.1), Eq. (A.2), etc.; in a subsequent appendix, Eq. (B.1) and so on. Similarly for tables and figures: Table A.1; Fig. A.1, etc.

Essential title page information

• ***Title.*** Concise and informative. Titles are often used in information-retrieval systems. Avoid abbreviations and formulae where possible.

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Abstract

A concise and factual abstract is required. The abstract should state briefly the purpose of the research, the principal results and major conclusions. An abstract is often presented separately from the article, so it must be able to stand alone. For this

reason, References should be avoided, but if essential, then cite the author(s) and year(s). Also, non-standard or uncommon abbreviations should be avoided, but if essential they must be defined at their first mention in the abstract itself.

Keywords

Immediately after the abstract, provide a maximum of 6 keywords, using American spelling and avoiding general and plural terms and multiple concepts (avoid, for example, 'and', 'of'). Be sparing with abbreviations: only abbreviations firmly established in the field may be eligible. These keywords will be used for indexing purposes.

Acknowledgements and Author Contribution

Collate acknowledgements in a separate section at the end of the article before the references and do not, therefore, include them on the title page, as a footnote to the title or otherwise. List here those individuals who provided help during the research (e.g., providing language help, writing assistance or proof reading the article, etc.).

References

Reference style

Text: Citations in the text should follow the referencing style used by the American Psychological Association. You are referred to the Publication Manual of the American Psychological Association, Seventh Edition, ISBN 978-1-4338-3215-4, copies of which may be ordered online.

List: references should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters 'a', 'b', 'c', etc., placed after the year of publication.

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To foster transparency, we encourage you to state the availability of your data in your submission. This may be a requirement of your funding body or institution. If your data is unavailable to access or unsuitable to post, you will have the opportunity to indicate why during the submission process, for example by stating that the research data is confidential.