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Research Paper

Neighbourhood blue space and mental health: A nationwide ecological study of antidepressant medication prescribed to older adults

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HIGHLIGHTS

- Investigation of blue space availability and older adult mental health using national antidepressant prescribing data.
- High neighbourhood freshwater coverage associated with lower antidepressant prevalence.
- Lower antidepressant prevalence observed in communities close to coasts and large lakes.
- Blue space merits further consideration in public health and urban planning policies.

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ABSTRACT

As global populations age rapidly, older adult mental health is becoming an increasingly important public health issue. The consequences of poor mental health in later life are severe and include reduced physical and cognitive functioning and greater risk of morbidity and mortality. Neighbourhood characteristics, such as the presence of aquatic environments - or 'blue spaces' - can positively impact mental health. However, evidence supporting the potential of neighbourhood blue space to promote mental health among older adults remains tentative. This study used negative binomial regression modelling to quantify the association between multiple metrics of neighbourhood blue space availability and antidepressant medication prevalence among older adults in Scotland. The study combined nationwide antidepressant prescription data for over two million older adults and geospatial data of blue space availability for over six thousand neighbourhoods and adjusted for a range of demographic and socioeconomic covariates. The availability of both freshwater and coastal blue space was associated with lower antidepressant medication prevalence among older adults in Scotland. Specifically, high neighbourhood freshwater coverage (>3%) ($p < 0.001$) and residing in close proximity (<1 km) to the coast ($p < 0.001$) and large freshwater lakes ($p < 0.05$) was associated with lower antidepressant medication prevalence. Our findings also suggest that neighbourhood blue space availability may have a greater impact on antidepressant medication prevalence among older adults than neighbourhood green space availability. Freshwater and coastal blue space, therefore, merit greater consideration in public health and urban planning policy and in the design of environments that aim to promote mental health and healthy aging.

1. Introduction

Globally, almost one in three adults (29%) will experience a common mental disorder, such as depression, at some point in their lifetime (Steel et al., 2014). Older adult mental health is becoming an increasingly important public health concern as global populations age rapidly (United Nations, 2019). The consequences of mental ill-health in older adulthood are severe and include reduced physical and cognitive functioning, lower quality of life and greater risk of dementia, morbidity and mortality (Fiske, Wetherell, & Gatz, 2009; Blazer, 2003: Wu et al.,

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2020). Despite this, older adults are often overlooked in mental health research (Villagrasa et al., 2019).

The environments or neighbourhoods where individuals live have been shown to affect both physical and mental health (Duncan and Kawachi, 2018; Dempsey, Devine, Gillespie, Lyons, & Nolan, 2018; Aerts et al., 2020). Neighbourhood environments may be particularly important for the health and well-being of older adults, as reductions in mobility and lifestyle changes in older age can increase time spent in the neighbourhood and result in greater reliance on neighbourhood resources (Glass and Balfour, 2003; Yen, Michael, & Perdue, 2009; Barnett et al., 2020). Neighbourhoods that encourage and facilitate contact with nature and the multiple ecosystem services offered by the natural environment may be highly suited to promoting mental health (Bratman et al., 2019; Frumkin et al., 2017). Indeed, positive mental health outcomes have been reported as a result of living in greener neighbourhoods (Beyer et al., 2014; Gascon, Zijlema, Vert, White, & Nieuwenhuijsen, 2015) and neighbourhoods with more accessible public green spaces (Wood, Hooper, Foster, & Bull, 2017; Nutsford, Pearson, & Kingham, 2013). Greater neighbourhood green space availability has also been associated with improved mental health for older adults specifically (Astell-Burt, Feng, & Kolt, 2013).

Neighbourhoods that support interactions with water bodies or 'blue spaces' may also provide benefits for mental health (Gascon et al., 2017; Völker and Kistemann, 2011; White et al., 2020: Foley and Kistemann, 2015). Blue spaces are frequently defined as 'outdoor environments – either natural or manmade – that prominently feature water and are accessible to humans' (Grellier et al., 2017). A systematic review of 36 studies, 12 focusing specifically on mental health, found limited evidence supporting a positive influence of blue space exposure on mental health (Gascon et al., 2017). However, a number of more recent studies have highlighted significant associations between access and exposure to neighbourhood blue space and positive mental health outcomes (Vert et al., 2020; Pasanen et al., 2019; Pearson et al., 2019), although such a relationship is not always observed (Gascon et al., 2018; Dzhambov et al., 2018).

There is a small but growing body of evidence demonstrating the potential mental health benefits of engaging with blue space in later life. Interacting with blue space regularly can promote emotional well-being during ageing (Coleman and Kearns, 2015) and provide restorative psychological effects and a sense of relaxation for older adults (Finlay, Franke, McKay, & Sims-Gould 2015). Older adults who regularly visit blue space report higher subjective well-being than older adults who never visit blue space (Garrett, White, et al., 2019). Older adults who live in residences with coastal views exhibit reduced symptoms of depression (Dempsey et al., 2018), whilst older adults living in neighbourhoods with higher freshwater availability (Chen and Yuan, 2020) and streets with visible blue space (Helbich et al., 2019) report more positive mental health outcomes. Despite this growing evidence base, research exploring the mental health promoting potential of blue space at different stages of older adulthood is lacking. Such research may be highly valuable given that mobility and accessibility related issues are common barriers to blue space usage in older adulthood (Pitt, 2018) and these barriers may increase with age (Yen et al., 2009).

Furthermore, some studies of blue space availability and older adult mental health focus solely on coastal (Dempsey et al., 2018) or freshwater environments (Chen and Yuan, 2020). In order to more fully understand the impact of neighbourhood blue space availability on older adult mental health, there is a growing need to independently quantify the potential for freshwater and coastal blue space to promote mental health and to contextualise these effects relative to each other and relative to a variety of other neighbourhood characteristics (McDougall, Quilliam, Hanley, & Oliver, 2020). The current evidence base would also be enhanced by establishing variations in the mental health-promoting potential of different freshwater blue space typologies. However, acquiring sufficient data to undertake this analysis remains a significant challenge (Mavoa et al., 2019). Indeed, studies of blue space availability and self-reported mental health can lack statistical power due to limited numbers within the sample living in close proximity to blue space (Triguero-Mas et al., 2015).

The use of objective health data, such as prescription or hospitalisation data, is becoming an increasingly popular method for quantifying the health and well-being effects of different neighbourhood characteristics, including blue and green space availability (Aerts et al., 2020; Pearson et al., 2019; Gidlow et al., 2016; Tarkiainen et al., 2020). Antidepressant medication is regularly prescribed in the treatment of common mental disorders (NHS Scotland, 2018) and small-area antidepressant prescription prevalence can, therefore, provide a useful indicator for ecological health research (Helbich et al., 2018). In a nationwide study of adults aged 15–65 in England, Gidlow et al. (2016) did not observe a significant association between antidepressant prescription volumes and the availability of blue and green space. Conversely, greater tree density (Taylor, Wheeler, White, Economou, & Osborne, 2015) and greater quantities of green space (Helbich et al., 2018) in residential areas in England and the Netherlands have been associated with lower antidepressant prescription rates. By providing large sample sizes and nationwide spatial coverage, antidepressant prescription data may be well suited to addressing knowledge gaps related to neighbourhood blue space availability and older adult mental health.

The aim of this study was to quantify the association between neighbourhood blue space availability and antidepressant medication prevalence for older adults in Scotland. The specific objectives were to: (i) quantify the effect of neighbourhood freshwater and coastal blue space availability on antidepressant medication prevalence among older adults; (ii) compare the effects of neighbourhood blue space availability on antidepressant medication prevalence between two older adult age categories (50–64 year-olds and > 65 year-olds); and (iii) contextualise the effects of different metrics of neighbourhood blue space availability on antidepressant medication prevalence relative to green space availability and a range of other demographic and socioeconomic neighbourhood characteristics.

2. Methodology

2.1. Study overview

This study adopted a nationwide cross-sectional ecological approach using a variety of 'small-area' statistics for Scotland. Data Zones (DZs) are the census geography and primary geographic unit for the dissemination of small-area statistics in Scotland ($n = 6976$). DZs are composed of approximately 500 to 1000 individuals. Antidepressant medication data for older adults was obtained for each DZ and analysed using zero-truncated negative binomial regression models to explore associations with metrics of blue and green space availability and a variety of socioeconomic and demographic covariates.

2.2. Study population

To identify potential differences in the effect of neighbourhood blue space availability on mental health at different stages of older adulthood, two older adult age categories (50–64-year-old and > 65-year-old) were analysed separately. Older adults are often categorised as individuals above the age of 60 for research purposes (Wolitzky-Taylor, Castriotta, Lenze, Stanley, & Craske, 2010). However, a wider definition was adopted given the need to understand the impact of blue space availability on mental health along the spectrum of older adulthood and in facilitating healthy aging (Finlay et al., 2015). The > 50-year-old threshold also coincides with previous blue space and health research (de Keijzer et al., 2019; Garrett, White, et al., 2019).

2.3. Antidepressant prescription data

Healthcare in Scotland is primarily provided via the National Health Service (NHS) which offers a variety of health services and medication freely at the point of delivery to patients. The number of 50–64-year-old and > 65-year-old individuals in each DZ that were prescribed at least one unit of antidepressant medication between 1st January and 31st December 2019 were the dependent variables in this study. Data was obtained from the Prescribing Information System for Scotland (PRISMS) and provided by Public Health Scotland. PRISMS holds data on NHS medication prescribed and dispensed in the community in Scotland and has a 98.8% capture rate for antidepressant medication (NHS Scotland, 2018). Antidepressant medication was identified using British National Formulary (BNF) section 4.3, which includes; (4.3.1) tricyclic and related antidepressant drugs; (4.3.2) monoamine-oxidase inhibitors; (4.3.3) selective serotonin re-uptake inhibitors; and (4.3.4) other antidepressant drugs.

2.4. Neighbourhood natural environmental availability

Neighbourhoods are regularly defined using Geographic Information Systems (GIS) by creating circular buffers surrounding the central point of an administrative zone, such as DZs or census tracts, or around an individual's residence (Labib et al., 2020). Multiple buffer sizes are often adopted in neighbourhood-health research (Duncan et al., 2018), but there remains little consensus on the most appropriate buffer size for quantifying blue space availability (Gascon et al., 2017). In this study, immediate and wider neighbourhood boundaries were represented by buffers around the most densely populated point, or population-weighted centroid (PWC), of each DZ (Fig. 1). The immediate neighbourhood was defined as a circular buffer with a radius of 800 m (Jansen, Kamphuis, Pierik, Ettema, & Dijst, 2018) which is approximately indicative of ten-minutes walking time (Dalton, Jones, Panter, Ogilvie, & Zhang, 2013) and the wider neighbourhood was defined using a 1600 m buffer (Mavoa et al., 2019).

2.4.1. Freshwater blue space

Following previous studies, neighbourhood freshwater coverage was calculated as a metric of freshwater blue space availability (Chen and Yuan, 2020; de Vries et al., 2016). Freshwater coverage was derived from the *Ordnance Survey (OS) Open Map - Local* dataset (Ordnance Survey, 2020a) and calculated as a percentage of surface area coverage in the immediate and wider neighbourhoods for each DZ. Previous research has analysed the presence vs absence of freshwater blue space (Pasanen et al., 2019), whilst other studies have categorised freshwater blue space coverage categorically (e.g. Garrett, Clitherow, et al., 2019). Given the abundance of freshwater resources in Scotland (>30,000 lakes) and the availability of high-resolution spatial data, this study considered a spectrum of freshwater blue space coverage. Neighbourhood freshwater coverage was defined using five categories to aid interpretation: (1) 0–0.25% (reference category); (2) > 0.25–0.75%; (3) > 0.75–1.5%; (4) > 1.5–3%; and (5) > 3%.

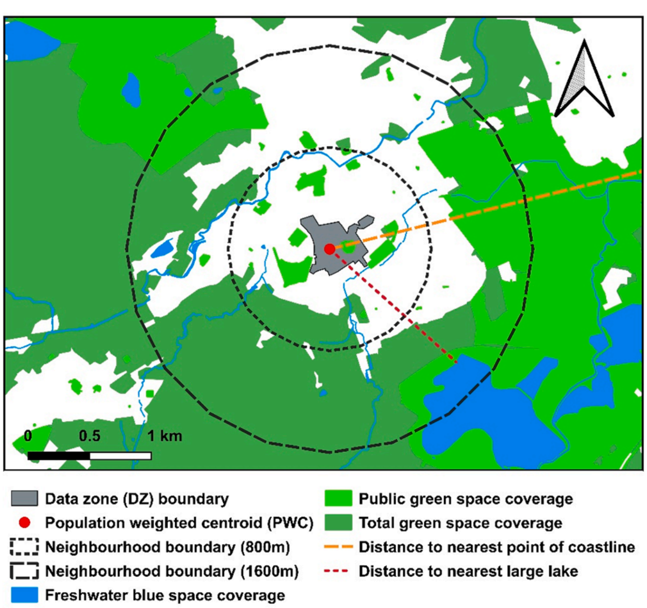

Fig. 1. Immediate (800 m) and wider (1600 m) neighbourhood boundaries and metrics of blue and green space availability. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

2.4.2. Large freshwater lakes

Proximity to large freshwater lakes was considered as an independent factor, since emerging evidence suggests living in close proximity to such features may provide mental health benefits (Pearson et al., 2019). Large lakes were defined as those with a surface area > 0.5 km^2 (50 ha), which includes approximately 350 of the largest freshwater lakes in Scotland. Proximity to large freshwater lakes was quantified by calculating the linear distance from the DZ PWC to the edge of the nearest large freshwater lake (Fig. 1). Proximity was operationalised using five categories: (1) > 20 km (reference category); (2) > 10 – 20 km; (3) > 5 – 10 km; (4) > 1 – 5 km; and (5) < 1 km. Distance categories were selected based upon an eighteen country study of blue space visitation patterns (Elliott et al., 2020) and extended to account for increased willingness to travel to large lakes in Scotland (McDougall, Hanley, Quilliam, Needham, & Oliver, 2020).

2.4.3. Coastal blue space

Coastal proximity was adopted as a metric of blue space availability as previous studies suggest that living in close proximity to the coast is associated with improved mental health among general populations (White, Alcock, Wheeler, & Depledge, 2013; Pasanen et al., 2019) and older adults specifically (Dempsey et al., 2018). Proximity to the coast was quantified as the linear distance from the DZ PWC to the nearest point of coastline. Due to the absence of an established defining point between freshwater and coast, Wheeler et al. (2012) define the beginning of the English coastline when the width of an estuary exceeds 1 km. However, given Scotland's fairly unique coastline, which encompasses multiple sea lochs (fjords) and wide inland river estuaries (e.g. the Firth of Forth), only estuaries with a width > 3 km were classified as coastal. Coastal proximity was defined using five categories; (1) 0–1 km; (2) > 1–5 km; (3) > 5–20 km; (4) > 20–40 km; (5) > 40 km (reference category) (Wheeler et al., 2012; Garrett, Clitherow, et al., 2019).

2.5. Covariates

2.5.1. Neighbourhood green space

The analysis adjusted for potential effects of green space coverage on the outcome variables, as greater green space coverage has previously been associated with lower antidepressant medication prevalence (Helbich et al., 2018; Taylor et al., 2015). Both total green space and public green space coverage were considered as the effects on mental health of exposure to each category can differ (Nutsford et al., 2013; Richardson and Mitchell, 2010). The *OS Open Greenspace* dataset (Ordnance Survey, 2020b) was used to identify the presence of public green space and included the following categories; allotments or community growing spaces, bowling greens, golf courses, other sports facilities, play spaces, playing fields and public parks. Public green space coverage was classified as the following; (1) 0–2.5% (reference category); (2) > 2.5–5%; (3) > 5–10%; (4) > 10–15%; and (5) > 15%. Data on total green space availability was derived from the Centre for Ecology & Hydrology (CEH) *Land Cover Map 2015* (minimum mappable unit: 0.5

ha) (Rowland et al., 2017) and converted to a percentage of immediate and wider neighbourhood coverage. In accordance with Dalton, Wareham, Griffin, and Jones (2016) total green space was defined as locations in which the dominant land use category was broadleaved or coniferous woodland, arable land, improved grassland, semi-natural grassland, mountain, heath or bog. Total green space coverage was defined using five categories; (1) 0–20% (reference category); (2) > 20–40%; (3) > 40–60%; (4) > 60 – 80%; (5) > 80% (Pasanen et al., 2019; Garrett, Clitherow, et al., 2019).

2.5.2. Urbanicity

The analysis adjusted for potential differences in common mental health disorder prevalence (Zijlema et al., 2015; Helbich et al., 2018) and antidepressant usage (Tarkiainen et al., 2020) related to neighbourhood urbanicity. The urbanicity of each DZ was designated using the Scottish Government Urban Rural Classification, which defines urban and rural areas as settlements with populations >3,000 people and <3,000 people, respectively (Scottish Government, 2018).

2.5.3. Demographic covariates

The analysis adjusted for area-level gender differences between DZs as older females are more likely to suffer from common mental disorders (Wolitzky-Taylor et al., 2010; Kiely, Brady, & Byles, 2019) and are more likely to receive antidepressant medication than older males (NHS Scotland, 2018). The percentage of females in each age category in each DZ was established using the *Mid-2018 Small Area Population Estimates* dataset, which provides population estimates by sex and age for small areas across Scotland (National Records of Scotland, 2019). Higher older adult mental health has been reported in neighbourhoods with a higher proportions of > 65-year-olds (Kubzansky et al., 2005). The proportion of adults above 65, which corresponds with current state pension age in Scotland, was calculated for each DZ to control for potential effects of DZ age composition on antidepressant medication prevalence.

2.5.4. Socioeconomic covariates

Neighbourhood socioeconomic characteristics have been found to impact older adult mental health (Yen et al., 2009). A variety of area-level socioeconomic indicators were derived from the 2020 release of the Scottish Index of Multiple Deprivation (SIMD) for each DZ. The proportion of income-deprived individuals was calculated for each DZ, as low socioeconomic status is a risk factor of common mental health disorders (Assari, 2017). Housing characteristics and living arrangements can also affect mental health and are particularly important to health and well-being for older adults (Howden-Chapman, Chandola, Stafford, & Marmot , 2011). The percentage of individuals in each DZ living in overcrowded housing was derived from the 2020 SIMD release. The analysis adjusted for crime rates as neighbourhood crime is a determinant of older adult mental health (Wilson-Genderson and Pruchno, 2013; Won, Lee, Forjuoh, & Ory, 2016). Higher neighbourhood crime rates have been associated with increased antidepressant medication prevalence in Scotland; however, this relationship is primarily attributed to the effects of crime on young and middle-aged adults (Baranyi et al., 2020). Crime rates for each DZ were extracted from the 2020 release of the SIMD. In instances where crime rate data was unavailable (n = 501), the crime rate from the nearest DZ was used.

2.6. Statistical analysis

Statistical and geospatial analyses were carried out in Stata (version 16.1) and QGIS (version 3.12 - București). Associations between antidepressant medication prevalence, metrics of blue space availability and potential covariates were analysed using zero-truncated negative binomial regression models due to the count nature of the dependent variable. Poisson models were rejected as overdispersal was present in the antidepressant medication data (Hilbe, 2011). Zero-truncation was required as data sensitivity restrictions disallowed antidepressant medication counts of zero in the dataset. The total population in the 50–64 and > 65 age brackets were included in the corresponding models as an offset variable (Mitchell and Popham, 2008; Wang and Tassinary, 2019). Associations between antidepressant medication prevalence and the explanatory variables were communicated using prevalence ratios (PR) (analogous to the risk ratio) and their respective confidence intervals (95% CI).

In total, four models were created which analysed associations between antidepressant medication prevalence and blue space availability for both age categories of older adults, using the immediate and wider neighbourhood definitions. The variables included in the modelling process and their hypothesised relationship with antidepressant medication prevalence are described in Table 1. Theoretical justification for the inclusion of each variable in the modelling process is provided in Sections 2.4 and 2.5. Inclusion of explanatory variables was reinforced by evaluating model performance using the Akaike information criterion (AIC) and Bayesian information criterion (BIC). Variance inflation factors (VIF) were analysed during the development of the final models to test for multicollinearity among variables.

3. Results

3.1. Descriptive statistics

Data protection required DZs with less than ten individuals being prescribed antidepressant medication in either age category to be excluded from the analysis. For the 50–64-year-old age category 6,891 DZs were included in the final analysis and 85 (1.2%) were removed. For the > 65-year-old age category 6,567 DZs were included in the final analysis and 409 (5.9%) were removed. The majority of removed DZs were in the lowest decile of population count for 50–64-year-olds (81.8%) and > 65-year-olds (88.1%). Given that missing antidepressant medication counts were, therefore, likely to be driven by low population in the relevant age category, rather than particularly low antidepressant medication prevalence, it was deemed appropriate to remove these DZs from further analysis.

Table 1
Description of variables used in the modelling process and hypothesised relationship with antidepressant medication prevalence.

Variable (expected direction of relationship)	Description
Antidepressant medication	Number of 50–64-year-old and > 65-year-old individuals within a DZ prescribed antidepressant medication in 2019.
Freshwater BS coverage (-)	Surface area of freshwater within neighbourhood.0–0.25% (ref); >0.25–0.75%; >0.75–1.5%; >1.5–3%; >3%
Distance to large lake (-)	Distance from neighbourhood PWC to large lake edge.>20 km (ref); >10 – 20 km; >5 – 10 km; >1 – 5 km; <1 km
Distance to coast (-)	Distance from neighbourhood PWC to coastline.>40 km (ref); >20 – 40 km; >5 – 20 km; >1 – 5 km; <1 km
Public GS coverage (-)	Surface area of public green space within neighbourhood.0–2.5% (ref); >2.5–5%; >5–10%; >10–15%; >15%
Total GS coverage (-)	Surface area of total green space within neighbourhood.0–20% (ref); >20–40%; >40–60%; >60–80%; >80%
Urbanicity (-)	Urbanicity of DZ.Urban (ref); rural
Proportion female (+)	Number of females in age category as a percentage of the total age group population.
Proportion state pension (-)	Percentage of DZ population above state pension age (>65).
Proportion low income (+)	Percentage of DZ population classified as income deprived.
Proportion overcrowded (+)	Percentage of DZ population living in overcrowded housing.
Crime rate (+)	DZ crime rate based on number of crimes per 1,000 people.

In total, data of 2,128,997 older adults were included in the final analysis, of which 517,856 (24.3%) received at least one unit of antidepressant medication in 2019. Table 2 displays descriptive statistics for all variables used in the modelling process for both age categories. On average the count of individuals in each age category in each DZ who received antidepressant medication was 41.16 for 50–64-year-olds and 35.67 for > 65-year-olds. When considered as proportion of the respective DZ population, antidepressant medication prevalence was higher among 50–64-year-olds (26.04%) than > 65-year-olds (23.72%). Fig. 2 compares three council areas (regional authorities) in Scotland that are representative of low (City of Edinburgh), moderate (Falkirk) and high (City of Glasgow) antidepressant medication prevalence. In the DZs considered in the 50–64-year-old analysis, mean freshwater blue space coverage was 2.13% in the immediate neighbourhood and 0.53% in the wider neighbourhood. On average DZs considered in the 50–64-year-old analysis were 11.32 km from a large lake and 20.03 km from the coast. Metrics of blue space availability in DZs used in the > 65-year-old analysis displayed virtually identical values (Table 2).

3.2. Antidepressant medication prevalence (50–64-year-olds)

The results of the regression analysis suggest all metrics of blue space availability were associated with lower antidepressant medication prevalence among 50–64-year-olds after controlling for potential demographic and socioeconomic confounders, with all results presented below including control for these confounders. A significant negative association was observed between high freshwater blue space coverage (>3%) and antidepressant medication prevalence in the immediate (Table 3) and wider neighbourhood models (Table 4). DZs with high freshwater blue space coverage in the immediate neighbourhood were significantly ($p < 0.001$) associated with 3.5% (PR = 0.9649, 95% CI 0.9498–0.9803) lower antidepressant medication prevalence than DZs with low freshwater blue space coverage (0–0.25%). In the wider neighbourhood model high freshwater blue space coverage was significantly ($p < 0.001$) associated with lower antidepressant medication prevalence by 5.5% (PR = 0.9421, 95% CI 0.9171–0.9678). Moderate freshwater blue space coverage (>1.5–3%) in immediate neighbourhood was associated with a 1.2% (PR = 0.9808, 95% CI 0.9648–0.9971) reduction in antidepressant medication prevalence ($p = 0.021$); however, no significant relationship was observed in the wider neighbourhood model.

DZs within 20 km of a large lake exhibited lower antidepressant medication prevalence in both the immediate and wider neighbourhood models. Based upon the immediate neighbourhood model, DZs within 1 km ($p = 0.021$) and 1 – 5 km ($p = 0.003$) of large lakes were significantly associated with 5.8% (PR = 0.9710, 95% CI 0.8947–0.9911) and 2.9% (PR = 0.9710, 95% CI 0.9522–0.9901) lower antidepressant medication prevalence, respectively, than DZs > 20 km from large lakes. Living between 10 km and 20 km ($p < 0.001$) and between 5 km and 10 km from large lakes ($p = 0.004$) was also associated with lower antidepressant medication prevalence relative to DZs > 20 km from large lakes. A similar relationship was observed for DZs within close proximity to the coast, although this was highly significant for all proximity categories ($p < 0.001$) and smaller confidence interval values were observed. Based on the immediate neighbourhood model, DZs within 1 km and > 1 km – 5 km of the coast reported reduced antidepressant medication prevalence by 4.5% (PR = 0.9508, 95% CI 0.9361–0.9747) and 5% (PR = 0.9508, 95% CI 0.9334–0.9685), respectively, relative to DZs > 40 km from the coast.

Mixed relationships were observed between neighbourhood green space coverage and antidepressant medication prevalence. In both the immediate and wider neighbourhood models, high public green space coverage (>15%) was significantly ($p < 0.001$) associated with lower prevalence of antidepressant medication among 50–64-year-olds. However, these values differed substantially between neighbourhood definitions. High public green space coverage in the immediate neighbourhood was associated with a 3.25% (PR = 0.9675, 95% CI 0.9509–0.9844) reduction in antidepressant medication prevalence, whilst public green space coverage in the wider neighbourhood was associated with a 6.2% (PR = 0.9383, 95% CI 0.9188–0.9582) reduction. Increasing total green space coverage in both the immediate and wider neighbourhood was positively associated with antidepressant medication prevalence, relative to low total neighbourhood green space coverage (0–20%). In the wider neighbourhood model all total green space categories were positively associated with antidepressant medication prevalence ($p < 0.001$). A similar relationship was observed for total green space coverage in the immediate neighbourhood model, with the exception of high green space coverage (>80%), which was associated with a 2.3% (PR = 0.9726, 95% CI 0.9441–1.0018) reduction in antidepressant medication prevalence. However, this was result was not significant at the 95% level ($p = 0.066$).

In both the immediate and wider neighbourhood models, all covariates (excluding crime rate and proportion of adults above state pension age) were highly significantly ($p < 0.001$) associated with antidepressant medication prevalence among 50–64-year-olds in the hypothesized direction proposed in Table 2. Based on the immediate neighbourhood model, 4.5% (PR = 0.9555, 95% CI 0.9347–0.9768) lower antidepressant medication prevalence was observed in rural DZs compared to urban DZs ($p < 0.001$). The immediate neighbourhood model also suggests that a 1% increase in the percentage of income deprived adults in a DZ was associated with a 2.5% (PR = 1.0244, 95% CI 1.0236–1.0251) increase in antidepressant medication prevalence among 50–64-year-olds ($p < 0.001$).

3.3. Antidepressant medication prevalence (>65-year-olds)

A significant ($p < 0.05$) negative association was observed between

Table 2
Summary statistics for DZs used in the analysis of each older adult age category.

Variable	DZmean50–64 (n = 6891)	Std. Dev.50–64	DZmean65+ (n = 6567)	Std. Dev.65+
Antidepressant medication count	41.16	16.16	35.67	17.03
Freshwater BS coverage (800 m) (%)	2.13	5.53	2.14	5.60
Freshwater BS coverage (1600 m) (%)	0.53	1.38	0.54	1.40
Distance to large lake (km)	11.32	7.46	11.34	7.54
Distance to coast (km)	20.03	16.30	20.08	16.31
Public GS coverage (800 m) (%)	7.51	7.61	7.48	7.56
Public GS coverage (1600 m) (%)	7.65	6.58	7.61	6.57
Total GS coverage (800 m) (%)	36.59	27.16	37.12	27.15
Total GS coverage (1600 m) (%)	46.90	27.44	47.61	27.27
Proportion age group female (%)	51.50	4.75	55.03	4.90
Proportion state pension (%)	19.53	7.74	20.17	7.35
Proportion low income (%)	12.39	9.61	12.52	9.57
Proportion overcrowded (%)	10.80	7.65	10.52	7.17
Crime rate (per 1000)	29.44	34.52	28.80	30.00

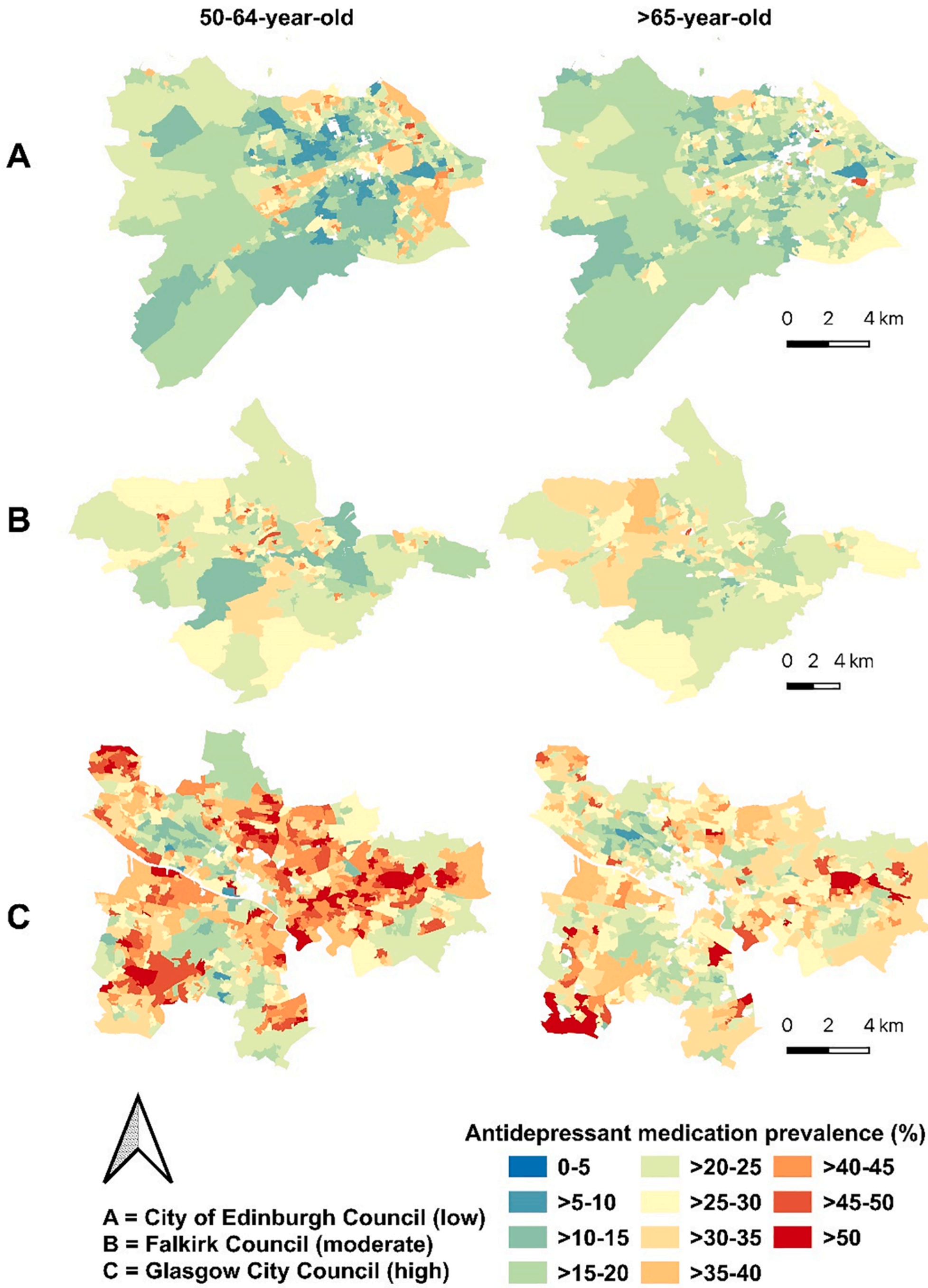

Fig. 2. Comparison of low (City of Edinburgh), moderate (Falkirk) and high (Glasgow City) antidepressant medication prevalence across council areas and age categories.

high freshwater blue space coverage in the immediate neighbourhood and antidepressant medication prevalence among > 65-year-olds (Table 5). High freshwater blue space coverage in the immediate neighbourhood was associated with a 1.9% (PR = 0.9810, 95% CI 0.9640–0.9984) reduction in antidepressant medication prevalence. In contrast to the 50–64-year-old model, no significant associations were observed for high freshwater blue space coverage in the wider neighbourhood (Table 6). Furthermore, no lower quantities of freshwater coverage (<3%) were significantly associated with antidepressant medication prevalence at the 95% level in the immediate or wider neighbourhood models.

Significantly lower antidepressant medication prevalence among > 65-year-olds was observed in DZs located in close proximity (<1 km) to large freshwater lakes (p = 0.013). The immediate neighbourhood model suggests DZs in close proximity to large lakes exhibit antidepressant medication prevalence 7% (PR 0.9299, 95% CI 0.8784–0.9845) lower than DZs > 20 km from large freshwater lakes. DZs between 10 km and 20 km from large freshwater lakes also exhibited 2.4% (PR 0.9764, 95% CI 0.9586–0.9944) reductions in antidepressant medication prevalence (p = 0.011). However, in contrast to the 50–64-year-old age category, no significant relationship was observed for DZs located between 1 km and 10 km from large freshwater lakes.

In accordance with the results of the 50–64-year-old age category models, decreasing coastal proximity was related to lower antidepressant medication prevalence. The immediate neighbourhood model suggests DZs closest to the coast (<1 km) exhibit 6.5% (PR = 0.9352,

Table 3
Immediate neighbourhood determinants of antidepressant medication prevalence (50–64-year-old) displayed as prevalence ratios (PRs).

50–64 (immediate neighbourhood)	PR	p value	95% CI
Freshwater BS coverage			
0–0.25% **(ref) (low coverage)**	1.0000	.	.
>0.25–0.75%	0.9941	0.391	0.9807–1.0077
>0.75–1.5%	0.9914	0.265	0.9765–1.0066
>1.5–3%	0.9808	0.021	0.9648–0.9971
>3% **(high coverage)**	0.9649	<0.001	0.9498–0.9803
Distance to large lake			
>20 km **(ref)**	1.0000	.	.
>10–20 km	0.9523	<0.001	0.9364–0.9685
>5–10 km	0.9750	0.004	0.9582–0.9920
>1–5 km	0.9710	0.003	0.9522–0.9901
<1 km	0.9417	0.021	0.8947–0.9911
Distance to coast			
>40 km **(ref)**	1.0000	.	.
>20–40 km	0.9832	0.027	0.9686–0.9981
>5–20 km	0.9797	0.011	0.9644–0.9953
>1–5 km	0.9508	<0.001	0.9334–0.9685
<1 km	0.9552	<0.001	0.9361–0.9747
Public GS coverage			
0–2.5% **(ref) (low coverage)**	1.0000	.	.
>2.5–5%	0.9958	0.608	0.9800–1.0119
>5–10%	0.9941	0.446	0.9792–1.0093
>10–15%	1.0045	0.619	0.9868–1.0225
>15% **(high coverage)**	0.9675	<0.001	0.9509–0.9844
Total GS coverage			
0–20% **(ref) (low coverage)**	1.0000	.	.
>20–40%	1.0267	<0.001	1.0127–1.0409
>40–60%	1.0220	0.004	1.0068–1.0374
>60–80%	1.0412	<0.001	1.0192–1.0637
>80% **(high coverage)**	0.9726	0.066	0.9441–1.0018
Urban	0.9555	<0.001	0.9347–0.9768
Proportion female (%)	1.0074	<0.001	1.0063–1.0085
Proportion state pension (%)	0.9988	0.002	0.9981–0.9996
Proportion low income (%)	1.0244	<0.001	1.0236–1.0251
Proportion living overcrowded (%)	1.0081	<0.001	1.0071–1.0092
Crime rate	0.9998	0.011	0.9996–0.9999
Constant	0.1276	<0.001	0.1196–0.1362
Observations	6891		
Pseudo R^2	0.1351		

Table 4
Wider neighbourhood determinants of antidepressant medication prevalence (50–64-year-old) displayed as prevalence ratios (PRs).

50–64 (wider neighbourhood)	PR	p value	95% CI
Freshwater BS coverage			
0–0.25% **(ref) (low coverage)**	1.0000	.	.
>0.25–0.75%	0.9914	0.168	0.9792–1.0037
>0.75–1.5%	0.9804	0.055	0.9608–1.0004
>1.5–3%	0.9770	0.097	0.9505–1.0042
>3% **(high coverage)**	0.9421	<0.001	0.9171–0.9678
Distance to large lake			
>20 km **(ref)**	1.0000	.	.
>10–20 km	0.9508	<0.001	0.9350–0.9670
>5–10 km	0.9744	0.003	0.9575–0.9915
>1–5 km	0.9666	<0.001	0.9478–0.9858
<1 km	0.9528	0.065	0.9052–1.0030
Distance to coast			
>40 km **(ref)**	1.0000	.	.
>20–40 km	0.9859	0.063	0.9713–1.0008
>5–20 km	0.9839	0.045	0.9684–0.9996
>1–5 km	0.9558	<0.001	0.9382–0.9737
<1 km	0.9592	<0.001	0.9394–0.9794
Public GS coverage			
0–2.5% **(ref) (low coverage)**	1.0000	.	.
>2.5–5%	1.0041	0.648	0.9865–1.0221
>5–10%	0.9923	0.366	0.9759–1.0090
>10–15%	0.9861	0.158	0.9672–1.0054
>15% **(high coverage)**	0.9383	<0.001	0.9188–0.9582
Total GS coverage			
0–20% **(ref) (low coverage)**	1.0000	.	.
>20–40%	1.0471	<0.001	1.0306–1.0640
>40–60%	1.0518	<0.001	1.0345–1.0693
>60–80%	1.0557	<0.001	1.0363–1.0755
>80% **(high coverage)**	1.0427	<0.001	1.0152–1.0708
Urban	0.9355	<0.001	0.9161–0.9553
Proportion female (%)	1.0075	<0.001	1.0064–1.0086
Proportion state pension (%)	0.9989	0.005	0.9982–0.9997
Proportion low income (%)	1.0240	<0.001	1.0233–1.0248
Proportion living overcrowded (%)	1.0092	<0.001	1.0082–1.0103
Crime rate	0.9998	0.034	0.9996–1.0000
Constant	0.1229	<0.001	0.1151–0.1312
Observations	6891		
Pseudo R^2	0.1358		

95% CI 0.9147–0.9563) lower antidepressant medication prevalence ($p < 0.001$) relative to inland DZs (>40 km). Whilst DZs between > 1 – 5 km ($p < 0.001$) and > 5 – 20 km ($p = 0.011$) from the coast report 5.5% (PR = 0.9453, 95% CI 0.9258–0.9653) and 3% (PR = 0.9709, 95% CI 0.9537–0.9883) lower antidepressant medication prevalence, respectively.

The relationship between neighbourhood green space coverage and antidepressant medication prevalence among over 65-year olds was similar to that observed for 50–64-year olds. High public green space coverage in the wider neighbourhood was significantly ($p < 0.05$) associated with lower antidepressant medication prevalence, relative to low public green space coverage in the immediate neighbourhood. High public green space coverage in the immediate neighbourhood was associated with a 1.7% reduction in antidepressant medication prevalence; however, this was result was not significant at the 95% level ($p = 0.089$). With the exception of high total green space coverage in the immediate neighbourhood, all categories of total green space coverage were significantly associated with higher antidepressant medication prevalence relative to DZs with low total green space coverage.

In both the immediate and wider neighbourhood models, all confounding variables (except crime rate and percentage of DZ population above state pension age) were significantly ($p < 0.001$) associated with antidepressant medication prevalence in the direction hypothesized in Table 1. A higher percentage of adults above state pension age was associated with lower antidepressant prevalence in both the immediate ($p = 0.081$) and wider neighbourhood ($p = 0.069$) models; however, these results were not significant at the 95% level. No significant relationship was observed between crime rate and antidepressant medication prevalence among over 65-year-olds in either model.

4. Discussion

Our study used a national dataset of antidepressant medication prescriptions to examine the relationship between neighbourhood blue space availability and older adult mental health. The study combined antidepressant prescription data for over two million older adults (over 50 years of age) and geospatial data of blue space availability for over six thousand neighbourhoods across Scotland. The findings suggest that neighbourhoods with higher blue space coverage and neighbourhoods located in close proximity to the coast and large freshwater lakes have lower antidepressant medication prevalence among older adults, even after controlling for potential demographic and socioeconomic confounders. By considering multiple metrics of blue space availability and utilising a large objective mental health dataset focused on older adults, our study makes novel contributions to current understanding of the potential of different natural environments (Finlay et al., 2015), blue space typologies (Mavoa et al., 2019) and neighbourhood characteristics (Motoc, Timmermans, Deeg, Penninx, & Huisman 2019) to promote mental health among older populations.

4.1. Principal findings

Collectively, the results of our study suggest greater neighbourhood blue space availability is associated with lower prevalence of

Table 5
Immediate neighbourhood determinants of antidepressant medication prevalence (>65-year-old) displayed as prevalence ratios (PRs).

>65 (immediate neighbourhood)	PR	p value	95% CI
Freshwater BS coverage			
0–0.25% **(ref) (low coverage)**	1.0000	.	.
>0.25–0.75%	0.9985	0.853	0.9834–1.0140
>0.75–1.5%	0.9936	0.457	0.9769–1.0106
>1.5–3%	0.9908	0.323	0.9729–1.0091
>3% **(high coverage)**	0.9810	0.032	0.9640–0.9984
Distance to large lake			
>20 km **(ref)**	1.0000	.	.
>10–20 km	0.9764	0.011	0.9586–0.9944
>5–10 km	0.9957	0.656	0.9770–1.0148
>1–5 km	1.0017	0.880	0.9804–1.0234
<1 km	0.9299	0.013	0.8784–0.9845
Distance to coast			
>40 km **(ref)**	1.0000	.	.
>20–40 km	0.9987	0.878	0.9817–1.0159
>5–20 km	0.9709	<0.001	0.9537–0.9883
>1–5 km	0.9453	<0.001	0.9258–0.9653
<1 km	0.9352	<0.001	0.9147–0.9563
Public GS coverage			
0–2.5% **(ref) (low coverage)**	1.0000	.	.
>2.5–5%	0.9983	0.851	0.9804–1.0164
>5–10%	1.0054	0.534	0.9885–1.0226
>10–15%	1.0050	0.626	0.9851–1.0253
>15% **(high coverage)**	0.9834	0.089	0.9645–1.0026
Total GS coverage			
0–20% **(ref) (low coverage)**	1.0000	.	.
>20–40%	1.0243	0.002	1.0087–1.0401
>40–60%	1.0303	<0.001	1.0131–1.0477
>60–80%	1.0435	<0.001	1.0188–1.0688
>80% **(high coverage)**	1.0004	0.980	0.9681–1.0338
Urban	0.9424	<0.001	0.9202–0.9651
Proportion female (%)	1.0119	<0.001	1.0107–1.0132
Proportion state pension (%)	0.9992	0.081	0.9983–1.0001
Proportion low income (%)	1.0119	<0.001	1.0109–1.0128
Proportion living overcrowded (%)	1.0042	<0.001	1.0028–1.0055
Crime rate	0.9999	0.440	0.9997–1.0001
Constant	0.1058	<0.001	0.0981–0.1141
Observations	6567		
Pseudo R^2	0.0611		

Table 6
Wider neighbourhood determinants of antidepressant medication prevalence (>65-year-old) displayed as prevalence ratios (PRs).

>65 (wider neighbourhood)	PR	p value	95% CI
Freshwater BS coverage			
0–0.25% **(ref) (low coverage)**	1	.	.
>0.25–0.75%	0.993	0.357	0.9799–1.0073
>0.75–1.5%	0.9902	0.394	0.9680–1.0129
>1.5–3%	0.9797	0.197	0.9496–1.0107
>3% **(high coverage)**	0.9795	0.165	0.9513–1.0086
Distance to large lake			
>20 km **(ref)**	1.0000	.	.
>10–20 km	0.9762	0.010	0.9584–0.9942
>5–10 km	0.9977	0.812	0.9789–1.0169
>1–5 km	1.0030	0.785	0.9816–1.0249
<1 km	0.9393	0.032	0.8870–0.9947
Distance to coast			
>40 km **(ref)**	1.0000	.	.
>20–40 km	1	0.999	0.9830–1.0173
>5–20 km	0.973	0.003	0.9556–0.9906
>1–5 km	0.9489	<0.001	0.9291–0.9691
<1 km	0.9427	<0.001	0.9212–0.9647
Public GS coverage			
0–2.5% **(ref) (low coverage)**	1.0000	.	.
>2.5–5%	1.0070	0.490	0.9873–1.0270
>5–10%	1.0112	0.237	0.9927–1.0301
>10–15%	1.0150	0.178	0.9933–1.0372
>15% **(high coverage)**	0.9741	0.028	0.9515–0.9972
Total GS coverage			
0–20% **(ref) (low coverage)**	1.0000	.	.
>20–40%	1.0234	0.011	1.0052–1.0420
>40–60%	1.0410	<0.001	1.0220–1.0603
>60–80%	1.0382	<0.001	1.0169–1.0600
>80% **(high coverage)**	1.0546	<0.001	1.0239–1.0862
Urban	0.9287	<0.001	0.9078–0.9502
Proportion female (%)	1.0122	<0.001	1.0109–1.0135
Proportion state pension (%)	0.9992	0.069	0.9983–1.0001
Proportion low income (%)	1.0117	<0.001	1.0108–1.0126
Proportion living overcrowded (%)	1.0046	<0.001	1.0032–1.0060
Crime rate	0.9999	0.422	0.9997–1.0001
Constant	0.1022	<0.001	0.0947–0.1104
Observations	6567		
Pseudo R^2	0.0613		

antidepressant medication and consequently, lower prevalence of mental ill-health, among a nationwide sample of older adults in Scotland. These findings are in contrast to previous research which failed to observe a significant relationship between access to blue space and common mental disorders or antidepressant usage among middle to older aged adults in Spain (Gascon et al., 2018). However, the findings are in alignment with a variety of studies that suggest access and exposure to blue space can benefit older adult mental health (Chen and Yuan, 2020; Dempsey et al., 2018; Helbich et al., 2019; Finlay et al., 2015).

Despite growing evidence of blue space engagement providing mental health benefits, researchers are often unable to quantify the precise mechanisms or pathways underlying this relationship. Potential pathways can be classified into three domains (Markevych et al., 2017) and include; (1) restoring capacities, e.g. blue space promoting relaxation, stress reduction and cognitive restoration (White et al., 2010; Felsten, 2009; Herzog, 1985; Finlay et al., 2015); (2) building capacities, e.g. blue space promoting social interaction (de Bell, Graham, Jarvis, & White, 2017; Pitt, 2018) and encouraging physical activity (Vert et al., 2019; Perchoux et al., 2015), which can support mental health in later life (Steinmo et al., 2014); and (3) reducing harm, e.g. blue space negating environmental stressors, such as noise, which can negatively affect older adult mental health (Pun et al., 2019). However, these pathways cannot be established from the data in our study and further research is required to confirm the mechanisms underlying the relationship between neighbourhood blue space availability and older adult mental health.

The results of our study also suggest neighbourhood blue space availability may have a greater impact on antidepressant medication prevalence than neighbourhood green space availability, replicating the findings of previous blue/green space exposure and mental health research (Nutsford, Pearson, Kingham, & Reitsma, 2016; Pasanen et al., 2019; de Vries et al., 2016). For example, de Vries et al. (2016) observed generally stronger associations between neighbourhood blue space coverage and mental health metrics than those observed for neighbourhood green space coverage in the Netherlands. Our findings may be explained by the adoption of relatively coarse measures of green space availability (Pasanen et al., 2019). Our study does not account for varying accessibility to green space or varying levels of green space quality, which are both important in terms of mental health promotion (Feng & Astell-Burt, 2018). Alternatively, experimental research suggests that blue space may be more effective than green space in terms of promoting cognitive restoration (White et al., 2010). Indeed, qualitative research suggests blue spaces may be particularly suited to promoting mental health, relaxation and stress reduction for older adults, whilst green spaces are highly suited to facilitating social interaction and exercise (Finlay et al., 2015). Despite this, current evidence is tentative and further research is required to fully understand the varying potential of exposure to blue and green space to promote mental health (Pasanen et al., 2019). Irrespective of any potential differences, exposure to blue and green space simultaneously is preferred to either individually (White et al., 2010) and both green and blue space are important components of environments that promote mental health and cognitive restoration (Deng et al., 2020).

4.2. Metrics of blue space availability

Despite growing evidence that access and exposure to blue space can offer health and well-being benefits, there has been little discussion on the potential of freshwater specifically to positively impact mental health (McDougall, Quilliam, Hanley, & Oliver, 2020). Our study suggests high neighbourhood freshwater coverage is associated with lower antidepressant medication prevalence among older adults. Other studies comparing mental health among neighbourhoods with and without freshwater, with no consideration of freshwater quantity, have obtained mixed results (Dzhambov et al., 2018; Pasanen et al., 2019). However, high freshwater coverage, but not low freshwater coverage, has been associated with fewer symptoms of depression and anxiety (Garrett, Clitherow, et al., 2019). Our research, therefore, further supports the notion that high neighbourhood blue space coverage is particularly suited to providing mental health benefits. Higher freshwater coverage may increase opportunities for engaging with freshwater incidentally or visually, which are key mechanisms in which blue space exposure can improve older adult mental health (Garrett, White, et al., 2019; Helbich et al., 2019).

High freshwater coverage in the wider (as distinct from immediate) neighbourhood was only associated with lower antidepressant prevalence among 50–64-year-olds, with no significant association observed for > 65-year-olds. A possible explanation for this might be related to less frequent blue space visitation beyond 10 min walking time (Völker et al., 2018), which coincides with the definition of the 'wider neighbourhood' adopted in this study. Increasing distance may be particularly important for the > 65-year-old age category as mobility is expected to reduce with increasing age (Gale et al., 2011). Indeed, older adults identify accessibility and mobility related issues as significant barriers to blue space usage and engagement (Pitt, 2018). In contrast to the wider neighbourhood, high freshwater coverage in the immediate neighbourhood may support more frequent blue space visitation, which has been associated with higher subjective well-being among older adults (Garrett, White, et al., 2019). High freshwater coverage in the immediate neighbourhood may also facilitate frequent and routine exposure to blue space, which can be particularly beneficial for > 65-year-old adults as such engagement can stimulate feelings of familiarity and security (Coleman and Kearns, 2015). The differing effects on antidepressant medication prevalence observed between older adult age categories in the wider neighbourhood models indicate a need for further research to quantify the impact of changing mobility patterns on freshwater blue space engagement throughout older adulthood.

Living in close proximity to large freshwater lakes has been associated with lower rates of anxiety / mood disorder related hospitalisation in North America (Pearson et al., 2019). In our study, living in close proximity to large lakes was associated with lower antidepressant medication prevalence among both age categories of older adults. This effect was most prominent in communities<1 km from large freshwater lakes, which is expected as visitation and, therefore, likelihood of exposure, decreases with increasing distance between the lake and residence (Elliott et al., 2020). This result contributes to a small body of evidence that suggests large freshwater lakes are particularly suitable for mental health promotion. This may be explained by the physical characteristics of large freshwater lakes. Firstly, an abundance of freshwater coverage makes large freshwater lakes highly visible relative to smaller waterbodies and, therefore, increases the likelihood of visually engaging with freshwater from the residence, during blue space visitation and throughout day-to-day activities, which can directly result in improved mental health among older adults (Helbich et al., 2019). Secondly, humans prefer views of blue spaces with larger surface areas compared to blue spaces with smaller surface areas (Herzog, 1985) and greater preference for larger blue spaces increases the likelihood of obtaining restorative benefits from engaging with these environments (van den Berg et al., 2003). Thirdly, most large freshwater lakes in Scotland are likely to be surrounded by vegetation and the combination of blue and green space has higher restorative potential than either environment in isolation (Deng et al., 2020; White et al., 2010).

Alternatively, the large freshwater lakes considered in our study may generally be of high blue space quality. Blue space quality refers to the potential of an aquatic environment to promote health and well-being and combines environmental considerations such as scale of water views and sense of wildness, with social and physical characteristics related to the availability of facilities, safety, accessibility and quality of the surrounding road network (Mishra et al., 2020). Given that many large freshwater lakes in Scotland are national tourist attractions and popular recreational sites, higher blue space quality and, therefore, greater mental health and well-being promoting potential can be expected. Indeed, high quality facilities are a key driver of blue space visitation among older adults (Garrett, White, et al., 2019).

As expected, lower antidepressant medication prevalence was observed for DZs in close proximity to the coast, aligning with previous studies demonstrating a positive coastal effect on mental health among general populations (White et al., 2013; Garrett, Clitherow, et al., 2019; Pasanen et al., 2019) and older adults (Dempsey et al., 2018). Given that low antidepressant medication prevalence is indicative of the absence of poor mental health rather than the presence of high mental well-being, the results of this study further reinforce the potential of coastal access to reduce negative mental health outcomes (Garrett, Clitherow, et al., 2019; White et al., 2013). Interestingly, similar reductions in antidepressant medication prevalence were observed for DZs in close proximity to the coast and DZs in close proximity to large freshwater lakes. This may be explained by the physical and visual similarities of these environments e.g. abundance of water coverage and expansive water views. Furthermore, the results of our study suggest coastal proximity has a greater effect on antidepressant medication prevalence than high neighbourhood freshwater coverage for both categories of older adults. This is in contrast to previous research which noted similar mental health impacts of coastal proximity and high freshwater coverage in England (Pasanen et al., 2019). Our study, therefore, contributes towards identifying differences in the mental health promoting-capacity of coastal and freshwater blue space, which is required to fully understand the potential of blue space to improve health and well-being (Mavoa et al., 2019) and to underpin future policy (McDougall, Quilliam, Hanley, & Oliver, 2020)().

4.3. Policy implications and future work

Although, it is important to note that the ecological design of our study does not allow conclusions to be drawn at an individual health-level (Aerts et al., 2020), the findings suggest the availability of both freshwater and coastal blue space may be beneficial for older adult mental health and reinforce suggestions that blue space merits greater consideration in public health and urban planning policy (Finlay et al., 2015). Indeed, promoting blue space engagement offers policy makers opportunities to improve mental health and facilitate healthy ageing among older adults (Costello, McDermott, Patel, & Dare, 2019). Moreover, the physical, psychological and social benefits of blue space exposure may be particularly valuable for the treatment of common mental health disorders, such as depression, as effective treatment in older adults requires the consideration of issues related to both psychosocial and physical morbidity (Büchtemann, Luppa, Bramesfeld, & Riedel-Heller, 2012).

Given the potential of blue space to promote public health, policymakers are faced with the challenge of increasing opportunities for blue space exposure and reducing barriers for blue space access for older adults and general populations. This can be achieved partly by placing greater emphasis on blue space accessibility and visual and auditory blue space exposure in the urban design (Deng et al., 2020) and by considering blue space provision in the location of new settlements; however, this will only likely be appropriate in urbanising and developing areas. Environmental restoration and urban regeneration projects could also place greater focus on blue (or blue/green) space provision and enhancement. Where possible, such approaches should seek to identify opportunities to pair blue space provision with synergistic environmental solutions, e.g. the use of blue space in sustainable urban drainage systems. A greater challenge is ensuring opportunities for blue space access are equitable and available to all. Unique barriers to blue space access are present for certain demographic groups, including older adults (Pitt, 2018) and blue space visitation is less likely for socially disadvantaged groups (de Bell et al., 2017; Haeffner et al., 2017). Identifying and mitigating barriers to blue space access is, therefore, a critical policy step that is required to ensure the health and well-being benefits of blue space are available to all.

4.4. Limitations and considerations

As our study is cross sectional, causality cannot be established and future research using antidepressant medication data with longitudinal study design offers opportunities to establish casual links between neighbourhood blue space availability and older adult mental health. Despite efforts to adjust our models for major covariates, insufficient data availability did not allow the consideration of some potentially important socioeconomic indicators and environmental stressors that may impact antidepressant medication prevalence among older adults. For example, although our models adopt an area-based indicator of current income, we were not able to adjust for potential differences in wealth across households, which may be particularly important consideration given our focus on older adults. Furthermore, as our study utilised area-based data, individual-level covariates and individual exposures/interactions with blue and green space could not be considered and future research using individual-level and exposure data is encouraged. However, the data used in this study provides a unique and national-scale picture of associations between the natural environment and antidepressant medication prevalence.

Despite providing a valuable proxy for the prevalence of common mental health disorders, our dependent variable (antidepressant medication prevalence) is unable to account for individuals who do not seek medical treatment (Helbich et al., 2018) or in cases where purely non-pharmaceutical treatments, such as cognitive behavioural therapy, are adopted. Although the primary purpose of antidepressant medication is to treat common mental disorders, antidepressants can also be prescribed to treat other conditions, e.g. chronic pain and migraines (NHS Scotland, 2018). While this poses a risk of misclassification, the numbers are likely small. Furthermore, as only one type of medication (antidepressant medication) was considered in our study, we could not take into account other co– and multi-morbidities within the study population that may confound some of the relationships identified. Finally, our study did not consider the issue of blue space quality. Dedicated tools for measuring blue space quality, such as the BlueHealth Environmental Assessment Tool (BEAT) (Mishra et al., 2020), require site visits and this was not feasible given the national coverage of our study. The development and usage of GIS-based ex-situ indicators of blue space quality alongside health data offers scope to improve understanding of the importance of blue space quality in the promotion of health and well-being.

5. Conclusion

Our study utilised a national antidepressant prescription dataset to quantify the effects of neighbourhood blue space availability on older adult mental health. The findings suggest that multiple metrics of neighbourhood blue space availability are associated with lower antidepressant prevalence among older adults in Scotland. Neighbourhoods with high freshwater blue space coverage and neighbourhoods in close proximity to large lakes and coastal environments consistently show lower antidepressant prevalence among the older adult population. These findings make several important contributions to current understanding of blue space availability and mental health. Collectively, the results of our study contribute towards a growing body of evidence that suggests access and exposure to both coastal and freshwater blue space can play an important role in promoting mental health in later life. Freshwater and coastal blue space, therefore, merit greater consideration in public health and urban planning policy and in the design of environments that aim to promote mental health and healthy aging.

6. Author statement

This study is the first to utilise a national antidepressant prescribing dataset to quantify the potential of freshwater and coastal blue space to promote mental health among older adults. Uniquely, we classify blue space into three categories with differing landscape features; freshwater, coastal and large lake. By broadening understanding of the potential of different aquatic environments to promote mental health, our paper undoubtedly assists the promotion and design of aquatic-inclusive sustainable solutions for landscape change and the provision of mutually supportive outcomes for nature and people (of all ages).

Declaration of Competing Interest

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

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