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Public greenspace and mental wellbeing among mid-older aged adults: Findings from the HABITAT longitudinal study

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ABSTRACT

We explored temporal associations between public greenspace and adults' mental wellbeing. Participants (n = 5,906) aged 40–65 years at baseline had data at >2 post-baseline waves of HABITAT, a multilevel longitudinal study (2007–16) in Brisbane, Australia. Participants self-reported mental wellbeing (short Warwick-Edinburgh Mental Wellbeing Scale) and neighbourhood self-selection reasons at Waves 2–5 (2009-11-13-16). We examined associations between Δgreenspace (within 1 km of home) and Δmental wellbeing using a linear fixed effects model, adjusting for time-varying confounders. Mental wellbeing increased (β = 1.75; 95% Confidence Interval:0.25–3.26) with greenspace exposure, adjusting for self-selection. Urban planning and policy initiatives to increase public greenspace may benefit mental wellbeing.

1. Introduction

Mental health conditions contribute significantly to the Global Burden of Disease (GBD). Prior to the COVID-19 pandemic, 4.3% of GDB was attributable to depression, the most pervasive individual cause of disability (accounting for 11% of years lived with disability) (WHO, 2013). Pre-pandemic, Australian data reflected the global situation with mental health disorders contributing to 12% of the total burden of disease (AIHW. Australia, 2016). Potentially, these contributions are likely to increase, since there were increases of 26–28% in the prevalence of depression and anxiety early in the pandemic (WHO, 2023).

Mental wellbeing, which is a construct distinct from mental health disorders (such as depression, anxiety, and psychological distress), combines aspects of hedonic wellbeing such as happiness, pleasure and satisfaction with life, and eudaimonic wellbeing which includes one's sense of purpose and realization of one's potential (Ryan and Deci, 2001; Henderson and Knight, 2012). Mental wellbeing is therefore not solely an indicator of lack of mental illness, but rather comprises multiple positive facets of mental health that help one to thrive mentally and experience fulfilment (Henderson and Knight, 2012). Favourable mental wellbeing at the population level is associated with longevity within productive, wealth-generating and cohesive societies (Houlden et al., 2018). To promote mental wellbeing in ageing populations across the world (United Nations DoEaSA and Population Division, 2019) and reduce the potential impact of some adverse mental health on health services, it is of critical importance to identify preventive, population-based strategies, along with clinical approaches. One possible avenue is the design or modification of the built environment to increase residents' exposure and access to greenspace and greenery.

There is an emerging body of research that suggests that exposure to greenspace is beneficial to both physical and mental health. Physical health benefits identified by a systematic review include reduced risk of

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all-cause mortality, cardiovascular disease, type-2 diabetes and premature birth (Twohig-Bennett and Jones, 2018). Evidence also suggests that blood pressure, cholesterol, nervous system activity, mental fatigue, and stress can all be reduced by spending time in natural environments or by walking in parks, and that exposure to greenspace can promote positivity and optimism (Twohig-Bennett and Jones, 2018; Maller et al., 2006). A further study of middle-to-older aged adults in Australia found that exposure to greenspace was associated with favourable mental health amongst those who reported being physically active on a regular basis (Astell-burt et al., 2013). In addition, local greenspace provides a setting for leisure-time physical activity (Koohsari et al., 2015). This may be particularly important to help older adults remain physically active and mobile (Rantakokko et al., 2016). A prospective study in UK has reported that exposure to neighbourhood greenspace may play a role in stemming declines in older adults' physical activity levels (Dalton et al., 2016).

A recent cross-sectional study in Beijing, China (Qin et al., 2021) found that exposure to greenery measured using the normalized difference vegetation index (NDVI) was directly associated with mental wellbeing and indirectly via two distinct mediators: physical activity and social cohesion within the local neighbourhoods. The findings suggest that the presence of and/or view of greenery may promote mental wellbeing, while green venues such as parks may be settings for physical activity and social interaction which are each also associated with mental wellbeing (Qin et al., 2021). Another cross-sectional study in London, UK (Houlden et al., 2019) found that greenspace within 300 m of home was positively associated with hedonic (life satisfaction, happiness) and eudaimonic (self-worth) components of mental wellbeing. A further cross-sectional study in Guangzhou, China (Wang et al., 2019) found that greenery measured objectively at the streetscape level using NDVI and also street view data were each associated with mental wellbeing, with mediating pathways via social cohesion and physical activity. Additional mediators of the association of greenery on streets were air quality, noise and stress (Wang et al., 2019).

Several theories (e.g. Stress Reduction Theory (Ulrich et al., 1983), Attention Restoration Theory (Kaplan, 1995)) and the Biophilia hypothesis (Wilson, 1984) help explain why time spent in greenspace promotes mental health and wellbeing. However, a systematic review (Houlden et al., 2018) reported a paucity of quality evidence on associations between greenspace and adults' mental wellbeing. This is partly due to the widespread use of unvalidated and/or proxy measures of mental wellbeing and inconsistency in measurement of exposure to greenspace (Houlden et al., 2018; Hartig et al., 2014).

As indicated above, most studies of greenspace and mental wellbeing are cross-sectional with the key limitation that causality cannot be inferred. There is limited longitudinal research that takes a casual inference approach (e.g. examining 'movers' who have relocated their residence, thus exposed to different levels of greenness). For example, a study in the UK examined the impact of relocating to greener or less green areas on mental health disorders (rather than mental wellbeing) (Alcock et al., 2014). It measured greenspace objectively and dichotomised movers as either moving to a greener area or a less green area. Relocating to a greener area was associated with ongoing improvements in mental health, while relocating to a less green area was associated with poorer mental health initially before returning to pre-move mental health status (Alcock et al., 2014). However, reasons why participants relocated were not included in analyses, and this was a limitation of that study (Alcock et al., 2014). Overall, natural experiments that measure residents' characteristics, including health-related factors, before and after they relocate, offer opportunities to infer causation between their local built/natural environments and aspects of their health (Rachele et al., 2018). Nevertheless, neighbourhood self-selection is recognised as a key confounder when examining associations between the built environment and health, hence their omission from these studies is a limitation (McCormack and Shiell, 2011).

The aim of the current study was to examine temporal associations between neighbourhood greenspace and mental wellbeing among adults aged 40–65 years, some of whom moved house and experienced variation in greenspace exposure. Our analysis accounted for reasons for neighbourhood self-selection, with these reasons being re-measured among those who moved during the study period.

2. Methods

2.1. Sample

Data were drawn from the multilevel longitudinal study (2007–16) titled 'How Areas in Brisbane Influence health And acTivity (HABITAT)'. Participants were residents of greater Brisbane, Australia and were aged 40–65 years at baseline (2007). The overarching aim of HABITAT was to explore change in physical activity, sedentary behaviour and participants' health, over the study period and how these outcomes were impacted, relatively, by built- and social environmental, sociodemographic and psychological characteristics.

Whilst details of the sampling design for HABITAT have been published previously (Burton et al., 2009), these are now described in brief. Using a multi-stage random sampling design with census data from the Australian Bureau of Statistics, a stratified random sample of 200 Census Collector's Districts (CCDs) was drawn from a total of 1625 CCDs. Then from the sampled CCDs, a total of 16,127 adults aged 40–65 years were identified as eligible to participate. The baseline questionnaire sent to these adults included (in addition to other core questions about physical activity and potential influences) questions on perceptions of their neighbourhood, history of residence, perceived health, sociodemographic information (e.g. age, sex (at birth), household composition) and individual socioeconomic characteristics (Burton et al., 2009). Using mail survey methodology developed by Dillman (2007), baseline questionnaires were mailed to all members of the sample and 11,035 questionnaires (i.e. 68% response rate) that reported useable data were received by the research team. The baseline data collection (2007) will be referred to henceforth as Wave 1. Four follow-ups of participants were conducted in the following years: 2009 (Wave 2); 2011 (Wave 3); 2013 (Wave 4) and 2016 (Wave 5).

The numbers of respondents who provided useable data (and response rates as a proportion of Wave 1 respondents) at each follow-up were: 7866 (71%) at Wave 2; 6900 (63%) at Wave 3; 6520 (59%) at Wave 4; and 5187 (47%) at Wave 5 (Turrell et al., 2021). At Wave 1, the mean number of private residences in each CCD was 203 (s.d. 81) (Burton et al., 2009). These CCDs were operationalised for this study as the immediate 'neighbourhood' of each participant. The median number of respondents per neighbourhood was 47 (range 12–161) at Wave 1.

Ethical approval for the HABITAT study was granted by the Human Research Ethics Committee of the Queensland University of Technology (Ref. No. 3967H and & 1300000161), and by the Human Research Ethics Committee of the Australian Catholic University (Ref. No. 2016-123T) for the 2016 data collection.

2.2. Measures

2.2.1. Outcome measure - mental wellbeing

Mental wellbeing was self-reported at Waves 2 to 5 using the short Warwick-Edinburgh Mental Wellbeing Scale (SWEMWBS) which asks participants about their mental wellbeing over the prior fortnight (Stewart-Brown et al., 2009). The scale comprises seven items measuring the relative frequency of participants' feeling (1) 'optimistic about the future', (2) 'useful', (3) 'relaxed'; (4) 'dealing with problems well'; (5) 'thinking clearly'; (6) 'feeling close to other people' and (7) being 'able to make up my own mind about things'. Response options and scores (in parenthesis) for each were: (1) 'None of the time'; (2) 'Rarely'; (3) 'Some of the time'; (4) 'Often'; (5) 'All of the time'. An overall score (with possible range of values 7 to 35) was computed for each wave by adding individual scores for each of the seven items and

applying the raw score to metric score conversion for this (Stewart-Brown et al., 2009). SWEMWBS has favourable psychometric properties including high internal reliability (Cronbach's alpha = 0.89) (Vaingankar et al., 2017).

2.2.2. Exposure measure – public greenspace

At each wave public greenspace, was operationalised as the area of parkland within a 1 km network buffer around each participant's home. This was objectively measured using Geographic Information System (GIS) software (ArcGIS Desktop 10.2. Redlands, CA 92373, USA: Environmental Systems Research Institute, 2011). Data for parkland at each wave were obtained from Brisbane City Council cadastres. In addition, to facilitate directional analysis, an indicator for change in public greenspace was derived to distinguish the following categories: those who moved and had an increase in greenspace; those who moved and experienced a decrease in greenspace, those who experienced minimal change in greenspace (i.e. less than 100 m^2 difference).

2.3. Covariates

2.3.1. Self-selection of neighbourhood

At Wave 1, participants were asked to respond to 14 survey items that examined possible reasons for choosing to reside in their current suburb. They were asked 'How important were each of the following in your decision to move to your suburb?' Possible reasons were: (1) affordability of housing land or rent; (2) investment potential; (3) safety from crime; closeness to (4) work, (5) school, (6) childcare, (7) the city, (8) public transport, (9) shops, (10) greenspace or bushland (native forest), (11) open space (e.g. parks), (12) recreational facilities; (13) ease of walking to places; (14) access to freeways (motorways) or main roads.

Responses were recorded using a five-point Likert scale: (1) 'Not at all important'; (2) 'A little important', (3) 'Somewhat important'; (4) 'Quite important'; (5) 'Very important'. Responses to all 14 items were entered into Principal Components Analysis with Varimax rotation. Eleven of these items were found to load on to three factors, referred henceforth as 'destinations', 'nature' and 'family facilities' that held across the five waves of data. The first factor, 'destinations', comprised six items (Cronbach's $\alpha = 0.82$) regarding proximity to work, the city, shops, public transport, access to motorways or main roads, and 'ease of walking to destinations'. The second factor 'nature' comprised two items (Cronbach's $\alpha = 0.90$) regarding proximity to greenspace and open space (including parks). The third factor 'family facilities' comprised two items (Cronbach's $\alpha = 0.57$) regarding proximity to schools and childcare facilities. Reasons for self-selection of a new neighbourhood were measured at any waves subsequent to residential relocation and corresponding factors scores were calculated for those waves, otherwise factor scores were the same as for the previous wave.

2.3.2. Neighbourhood disadvantage

The measure of neighbourhood disadvantage used in this study was based on the Index of Relative Socioeconomic Disadvantage (IRSD) for each neighbourhood (Census of Population and Housing, 2015). IRSD scores are derived from the Census of Population and Housing and indicate relative levels of disadvantage in Australia based on 17 socioeconomic factors that include proportions within each area of low income households, unemployed adults and those with no education qualifications beyond school (Census of Population and Housing, 2015). IRSD scores for all 200 HABITAT neighbourhoods were then enumerated as percentiles relative to all areas of Brisbane. Neighbourhoods were then categorised according to quintile relative to Brisbane: Q1 included the 20% least disadvantaged areas, while Q5 included the 20% most disadvantaged areas.

2.3.3. Education level

At Wave 1, participants were asked to report their highest education level. Responses were collapsed into the following categories: (1) None beyond school; (2) Certificate (trade/business); (3) Diploma (associate or undergraduate); (4) Bachelor's degree or postgraduate diploma/degree. Values for education level were carried through to all subsequent waves.

2.3.4. Occupation

At each wave, participants who were employed were asked the title of their current occupation. If they had multiple jobs they were asked to report the title of their main job. Occupations were coded using the Australian New Zealand Standard Classification of Occupations (ANZSCO) which has nine categories (ANZSCO, 2013). These were then collapsed into six categories: (1) managers/professionals (managers and administrators, professionals, para-professionals); (2) white collar workers (clerks, salespersons, personal service workers); (3) blue-collar workers (tradespersons, plant and machine operators and drivers, labourers and related workers); (4) household duties; (5) retired; or (6) not easily classifiable.

2.3.5. Household income

At each wave a single survey item listed 13 income categories from which participants were asked to choose the category that best represented their gross annual household income. These 13 categories were then collapsed into six categories: (1) $\geq$ AU$130,000, (2) AU $129,999–72,800; (3) AU$72,799–52,000; (4) AU$51,999–26,000; (5) $\leq$ AU$25,999; or (6) not classified (i.e. participant left this response blank, selected "Don't know" or "Don't want to answer this").

2.3.6. Living arrangement

At each wave, respondents were asked to report on their living arrangement. Response options were: (1) living alone with no children; (2) single parent living with one or more children, (3) single and living with friends or relatives, (4) couple (married/defacto) living with no children, (5) couple (married/defacto) living with one of more children, and (6) other.

2.3.7. Life events

At each wave after baseline, respondents were asked whether (yes/no) they had experienced the following life events (which may impact mental wellbeing) in the two years prior: separation/divorce from their partner, severe illness/injury of themselves, or severe illness/injury of a relative or close friend.

2.4. Data analyses

The analytic sample for the current manuscript comprised participants who recorded data at Wave 1 and at least two later waves, while residing in Brisbane. This was to allow analyses between at least two waves of change in mental wellbeing (which was not measured at Wave 1). Based on these criteria the final sample comprised 5,906 participants. Descriptive data for demographic variables were generated. A linear fixed-effects regression model with robust standard errors was used to estimate the association between changes in exposure to greenspace and changes in mental wellbeing, accounting for neighbourhood self-selection reasons. Due to their within-individual comparisons, fixed-effects models have the advantage of adjusting for all time-invariant confounding (e.g. sex), while time-varying confounders can be included in models. The model was fitted using Stata SE version 15 using the 'xtreg' command with fixed-effects estimators and robust standard errors. We planned, initially, to run the model with cluster-robust standard errors to adjust for neighbourhood-level clustering, but prior sensitivity analysis found no clustering within neighbourhoods among our analytic sample. Following this, in order to perform some directional analysis, we ran additional linear fixed effects models with the following subsets of the analytic sample: movers who experienced an increase in greenspace, and movers who had a decrease in greenspace.

3. Results

Baseline demographics of the analytic sample (i.e., those with data at Wave 1 and at least two more waves) and the full sample are presented in Table 1. On average, the analytic sample had a slightly higher proportions of managers/professionals (37%, compared with 33% of the full sample), and of people with a degree (35% compared with 31% of the full sample). Otherwise, there was little difference in characteristics between these groups; and these variables were adjusted for in the final analyses.

The distribution of mental wellbeing scores and greenspace variables by data collection wave is presented for our analytic sample in Table 2. Overall, on average mental wellbeing scores and area of greenspace were marginally higher at Waves 4 and 5 compared with Wave 2. Examining change in greenspace (final area – area at Wave 1) for each participant, 63.0% had an increase in greenspace, 19.6% had a reduction and 17.4% experience minimal change (i.e. magnitude of change was less 100 m^2; Table 3).

Results of the fixed effects regression modelling are presented in Table 4. There was a significant increase (β = 1.75; 95% Confidence Interval (CI) 0.25–3.26)) in the score for mental wellbeing within the same individual when they were exposed to greater amounts of greenspace, after adjusting for neighbourhood self-selection. This positive association between greenspace and mental wellbeing remained significant in the model for the subsample who had experienced an increase (of magnitude at least 100 m^2) in greenspace (β = 2.18 (95%CI 0.31, 4.05)), but there was no significant association for those experiencing a decrease (of magnitude at least 100 m^2) in greenspace (β = 0.56 (95%CI —2.92, 4.04). None of the self-selection factors (including the importance of nature for their choice in relocating) were significantly associated with mental wellbeing in these models.

Table 1
Sociodemographic characteristics of analytic sample and full sample at baseline.

Characteristic	Analytic sample (n = 5,906) Mean (sd) or %	Full sample (n = 11,035) Mean (sd) or %
Age (years)	51.5 (7.1)	51.2 (7.1)
Sex (Male)	43%	44%
Occupation		
Managers/professionals	37%	33%
White collar	22%	22%
Blue collar	13%	14%
Home duties	6%	6%
Retired	9%	9%
Not easily classifiable	13%	16%
Income		
≥AU$130,000	19%	17%
AU$129,999–72,800	29%	26%
AU$72,799–52,000	16%	15%
AU$51,999–26,000	17%	18%
≤AU$25,999	8%	9%
not classified	11%	15%
Education		
None beyond school	36%	39%
Certificate (trade/ business)	17%	18%
Diploma (associate or undergraduate)	12%	12%
Degree	35%	31%
Living arrangement		
Living alone with no children	15%	15%
Single parent living with child (ren)	6%	9%
Single, living with friends/relatives	4%	6%
Couple not living with children	30%	27%
Couple living with child (ren)	42%	42%
Other	3%	1%
Neighbourhood disadvantage		
Quintile 1 (least disadvantaged)	32%	30%
Quintile 2	19%	19%
Quintile 3	18%	19%
Quintile 4	19%	19%
Quintile 5 (most disadvantaged)	12%	13%

Table 2
Distribution of mental wellbeing score and public greenspace variables by data collection wave (analytic sample).

	Wave 2 Mean (SD)	Wave 3 Mean (SD)	Wave 4 Mean (SD)	Wave 5 Mean (SD)
Mental wellbeing[a]	23.32 (3.51)	23.24 (3.49)	23.87 (3.89)	23.85 (3.84)
Greenspace (km^2)[b]	0.063 (0.056)	0.078 (0.065)	0.082 (0.069)	0.078 (0.071)

[a] Score for shortened Warwick Edinburgh Mental Wellbeing Scale (SWEMWBS); possible range of values 5–35.
[b] Within 1 km network buffer of home.

Table 3
Indicators of change in public greenspace (analytic sample, n = 5,906).

Change in greenspace [a]	Freq (n = 5,906)	%
Decrease (of ≥100m^2)	1155	19.6
Minimal (Δ < 100m^2)	1028	17.4
Increase (of ≥100m^2)	3723	63.0

[a] Between Wave2 and latest wave of data collection.

Table 4
Public greenspace and mental wellbeing[a]: fixed effects linear regression model[b], HABITAT study 2007–2016.

	β	95% CI	p
Full analytic sample 18,773 observations; 5,906 participants			
Greenspace – within 1 km[c] of home	**1.75**	**0.25, 3.26**	**0.023**[c]
Neighbourhood self-selection reasons[d]			
– destinations	−0.01	−0.30, 0.27	0.920
– family facilities	0.002	−0.28, 0.29	0.986
– nature	0.05	−0.22, 0.33	0.709
Those with increase in greenspace 11,837 observations; 3,723 participants			
Greenspace – within 1 km[c] of home	**2.18**	**0.31, 4.05**	**0.022***
Neighbourhood self-selection reasons[d]			
– destinations	−0.03	−0.38, 0.33	0.881
– family facilities	0.09	−0.30, 0.49	0.642
– nature	0.07	−0.29, 0.44	0.697
Those with decrease in greenspace 3,710 observations; 1,155 participants			
Greenspace – within 1 km[c] of home	0.56	−2.92, 4.04	0.753
Neighbourhood self-selection reasons[d]			
– destinations	−0.23	−0.71, 0.26	0.366
– family facilities	−0.14	−0.56, 0.29	0.536
– nature	0.10	−0.33, 0.54	0.637

[a] Score for short Warwick Edinburgh Mental Wellbeing Scale.
[b] adjusted for age, occupation, living arrangement, life events (separation/ divorce, severe illness/injury), household income, neighbourhood disadvantage; education was omitted due to collinearity; CI, confidence interval. *p < 0.05.
[c] Network buffer.
[d] The reasons for choosing neighbourhood location were recorded at baseline (Wave 1), and updated at subsequent waves if the participant had moved house within Greater Brisbane.

4. Discussion

This study is novel in its examination of how objectively measured public greenspace in local neighbourhoods was related to changes in mental wellbeing among middle-to-older aged adults movers and non-movers, accounting for neighbourhood self-selection. Those who relocated within the study period experienced some variation in exposure to greenspace. However, by measuring public greenspace at each time-point and including non-movers in our analytic sample, there was potential to study those who experienced changes in greenspace from local redevelopment. For example, building construction may result in less greenspace, or reclamation of industrial space to build parks may result in more greenspace. Further, alterations to the road network (e.g. within 1 km of home) may render some public greenspace more accessible.

The significant positive association between mental wellbeing within the same individual and their exposure to varying amounts of public greenspace, accounting for neighbourhood self-selection reasons is an important finding. It suggests moving to a neighbourhood with higher levels of greenspace has a positive impact on mental wellbeing (independent of self-selection and other factors including the perceived importance of access to nature). Similarly, those who live in areas where parkland is added or expanded are also likely to experience an increase in mental wellbeing. Even though other studies have demonstrated positive associations between greenery and mental wellbeing (Qin et al., 2021; Houlden et al., 2019; Wang et al., 2019), our finding is particularly noteworthy because it is based on a longitudinal study of cohort members, some of whom moved, and measurement of public greenspace at each time point. This is akin to a natural experiment. We also used a fixed-effect approach which has strong causal inference properties. It was, perhaps, surprising that the neighbourhood self-selection reasons (in particular, proximity to parks and greenspace) were not associated with mental wellbeing. Whilst our models were adjusted for some major life events including separation and divorce, there may be other potential covariates that, for example, restrict access to public greenspace and compromise mental wellbeing.

From a policy perspective, it is important not to overstate the findings from one study, when any potential magnitude of improvements in mental well-being associated with greenspace are described. Despite being developed to monitor population-level mental wellbeing, the Short Warwick Edinburgh Mental Well-Being Scale (SWEMWBS) is shown to be responsive to change at an individual level (Shah et al., 2018). Based on longitudinal data from a clinical sample, it is reported that a change in SWEMWBS of between 1 and 3 points may be statistically meaningful (Shah et al., 2018). Our results suggest that a 1 km^2 increase in greenspace within 1 km (network buffer) of one's home would equate to an increase of 1.75 in the mental wellbeing score (SWEMWBS). Following this logic, for a conservative meaningful increase of 1 point in mental wellbeing to occur, an increase in greenspace of 0.571 km^2 would be required. To give this some context, this is equivalent to around 80 standard soccer pitches, according to international recommended field of play dimensions (area 105 × 68 m, i.e. 0.00714 km^2) (FIFA, 2022). The mean total area of 1 km network buffers within the HABITAT study was 1.136 (SD 0.413) km^2. Our overall finding with the full analytic sample suggests that for a significant improvement in mental wellbeing that is related to public greenspace, a person would need to relocate from a neighbourhood with little greenspace to one where on average, public greenspace accounts for around half of its area. This suggests that the more greenspace available, the better, which may be difficult to achieve in urban areas.

A study in New South Wales, by Astell-Burt and Feng (Astell-Burt and Feng, 2019) reported that tree canopy of 30%, was associated with positive mental health outcomes, but not access to greenspace per se. Thus, creating and maintaining green leafy neighbourhoods may be an easier policy solution for promoting mental health and wellbeing, than developing parkland. Despite many Australian cities, local and state governments requiring that residents have access to certain amounts of public open space (Arundel et al., 2017), only some jurisdictions (in South Australia and Victoria) have coverage targets for tree canopy (Henderson and Knight, 2012). More evidence is required to inform urban greening policies.

Strengths of this study include having a large sample of older adults with up to five waves of data collection gathered from participants over nine years. A limitation of our study is that it focuses only on public greenspace in the form of parklands, rather than overall greenery. Time spent in greenspace, in particular engaging in physical activity within greenspace was not measured in our study. There is evidence that physical activity may mediate associations between greenspace and mental wellbeing (Astell-Burt et al., 2013). Whilst parks may offer settings for physical activity and interaction with nature, the benefits of greenery and greenspace may come from other sources, such as private gardens and roadside vegetation which may help to offset the harmful effects of air pollution on health (Carver et al., 2024). Further longitudinal studies that examine the impact of the amount and quality of different types of greenspace or greenery (e.g. tree canopy, parkland, natural bushland) are vital to improve understanding of these associations and to guide the urban planning standards and determine the design of urban areas, which have the potential to promote mental wellbeing among residents and those who work there or frequent these areas. In addition, it is important to examine the quality of greenspace with regard to facilities (e.g. sports equipment and play spaces) and amenities (e.g. picnic tables, toilets) as these may influence use and time spent in greenspace (Sugiyama et al., 2018), and have been shown to be inequitably distributed across cities, depending upon socioeconomic status (Crawford et al., 2008).

5. Conclusion

We found some evidence of a beneficial longitudinal association between greenspace and mental wellbeing, accounting for neighbourhood self-selection reasons among mid-to-older aged adults. Thus, urban planning and environmental policy initiatives that aim to increase public greenspace may be beneficial for mental wellbeing.

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CRediT authorship contribution statement

Alison Carver: Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Conceptualization. **Jerome N. Rachele:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Takemi Sugiyama:** Writing – review & editing, Methodology, Formal analysis, Conceptualization. **Billie-Giles Corti:** Writing – review & editing, Visualization, Supervision, Investigation, Conceptualization. **Nicola W. Burton:** Writing – review & editing, Visualization, Supervision, Methodology, Data curation, Conceptualization. **Gavin Turrell:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Data curation, Conceptualization.

Data availability

Data will be made available on request.

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