**Can Neighborhood Green Space Mitigate Health Inequalities? A Study of Socio-Economic Status and Mental Health**


## ABSTRACT

This study examined whether the association of psychological distress with area-level socio-economic status (SES) was moderated by the area and attractiveness of local green space. As expected, the odds of higher psychological distress was higher in residents in lower SES areas than those in higher SES areas. However, our results were inconclusive with regard to the moderating role of green space in the relationship between psychological distress and SES. Further investigations incorporating safety and maintenance features of green space and street-level greenery are warranted.



## KEYWORDS

psychological distress; disparity; disadvantage; park; neighborhood environment

## BACKGROUND

Socio-economic disparities in health persist in society, and reducing health inequalities is recognized as a critical strategy for population health (Centers for Disease Control and Prevention, 2013; Marmot and Bell, 2012; National Preventative Health Taskforce, 2009). Despite public health efforts to reduce inequalities, systematic and avoidable health disparities exist between people of lower and higher levels socio-economic status (SES), who in definition differ in terms of access to material and social resources (Australian Bureau of Statistics, 2008). For example, in Australia, those who are in the lowest quintile in household income are 2 to 4 times more likely to suffer from long-term ill health than those in the highest quintile (Brown and Nepal, 2010). Socio-economic disparities also exist in mental health (Lorant et al., 2003). A Welsh study found that residents of lower income areas tended to have poorer mental health status than those in higher income areas (Fone et al., 2007). A Danish study also reported that lower income (bottom third) participants had 3.5 times higher odds of minor depression, and 8.5 times higher odds of major depression, relative to those with higher income (Andersen et al., 2009).

Neighborhood green spaces are important community assets that could contribute to residents' mental health, through a number of potential pathways (Lachowycz and Jones, 2013). For instance, exposure to nature is known to have restorative effects (Hansmann et al., 2007; Hartig et al., 2003). Physical activity and social interaction, often facilitated within local parks, are also associated with better mental health (Kawachi and Berkman, 2001; Penedo and Dahn, 2005). Research has shown positive associations between neighborhood green space and residents' mental health. Adults who perceived their neighborhood to be greener were found to have better mental health than those who perceived it less green (Sugiyama et al., 2008). Residents of

neighborhoods with a high-quality green space had lower levels of psychosocial distress than those of neighborhoods with a low-quality open space (Francis et al., 2012). Neighborhood greenness, measured using satellite imagery, was also found to be negatively associated with adult's stress levels (Fan et al., 2011). Similarly, a UK study found that participants living in areas with more green space tended to have lower perceived stress and a healthier cortisol measure (Roe et al., 2013).

The distribution and quality of green spaces across diverse SES areas may have implications in SES-related inequalities in mental health. Examining whether exposure to greener environments mitigates the health gap between disadvantaged and less disadvantaged neighborhoods, Mitchell and Popham (2008) found that inequalities in mortality and cardiovascular disease between areas of low and high deprivation (determined based on the proportion of low income households) were less pronounced among those who live in greener neighborhoods (Mitchell and Popham, 2008). A more recent study also found a narrower socio-economic inequality in mental well-being among those who reported better access to recreational/green areas (Mitchell et al., 2015). However, it is unknown how the size and attractiveness of local green spaces are related to mental health inequalities between lower and higher SES areas. We postulate that the relationship between psychological distress and SES will be less pronounced among participants who have greater amount and more attractive green space, because exposure to greenery may reduce psychological distress, which is more prevalent in lower SES areas. In addition, attractive green space may encourage residents to engage in recreational walking and physical activity, which are also known to be less prevalent in lower SES areas (Beenackers et al., 2012; Janssen et al., 2010).

This study examined whether the associations of residents' mental health (psychological distress)

with area-level SES were moderated by the size and quality of green space. We hypothesized that the relationship between psychological distress and SES is less pronounced (1) among participants with larger green space; (2) among those with attractive green space in their neighborhood.

## METHODS

### Data Source and Participants

This study forms part of the Life Course Built Environment and Health project, a cross-sectional data linkage study exploring associations between built environment features and health across different life stages (children through to older adults) in Perth, Western Australia. The overall project methods are described in detail elsewhere (Villanueva et al., 2013). Briefly, participants were those who completed the Western Australian Health and Wellbeing Surveillance System (HWSS) survey, administered by the Department of Health of Western Australia (DoHWA). The HWSS was conducted in 2003–09, collecting data from 21,347 participants, who were sampled randomly from the Perth metropolitan and Peel area. The data of built environment were linked to 75% of survey participants who consented to data linkage and had a geocoded home address (n=15,954). For this study, adults aged 18–64 years who completed one of the HWSS surveys conducted in 2005–09 were included (n=7,034). Those who participated in 2003 and 2004 were not included because some covariates used in this study were not asked in these years. Ethics approval was obtained from the Department of Health of Western Australia and The University of Western Australia.

### Outcome: Psychological Distress

The HWSS included the Kessler Psychological Distress Scale (K10), a 10-item scale intended to

assess non-specific distress based on questions about anxiety and depressive episodes that a person experienced in the past four weeks. This scale has been validated in the Australian population against clinical diagnoses of depressive symptom and anxiety disorder (Andrews and Slade, 2001), and has shown to have better discriminatory power than the GHQ-12 for screening DSM-IV mood and anxiety disorders (Furukawa et al, 2003). It has been also shown to have a high internal consistency, with Cronbach's alpha over 0.9 (Cornelius et al., 2013). Possible K10 scores ranged from 10–50, where a higher score indicates that a person may be experiencing higher levels of distress consistent with a diagnosis of a severe depression and/or anxiety disorder (Andrews and Slade, 2001). As there are no agreed standards for scoring the K10, this study adopted the K10 categories used in previous Australian health surveys (Australian Bureau of Statistics, 2012): "low" (10–15); "moderate" (16–21); "high" (22–29); and "very high" (30–50). Due to a small number of participants belonging to the very high category (2.5%), the high and very high categories were combined to create three levels: low, moderate, and high.

**Exposure: Area-Level Socio-Economic Status**

As an area-level indicator of SES, the Index of Relative Socio-economic Disadvantage (IRSD) was extracted for each census collection district (CCD) defined by the Australian Bureau of Statistics in 2006. The IRSD is a composite area-level socio-economic indicator consisting of factors such as income, education, employment, and car ownership, with lower scores pertaining to higher levels of disadvantage (Australian Bureau of Statistics, 2008). At the time of data collection, CCDs were the smallest geographic sub-units for census data collection, averaging approximately 225 dwellings in urban areas (Australian Bureau of Statistics, 2006). For the purpose of descriptive analysis, the CCDs in which participants resided were categorized into quartiles based on their IRSD score, and participants were grouped according to the quartile. The

IRSD was treated as continuous (standardized) for regression analysis, given that research has shown roughly a linear association between socio-economic status and psychological distress (Andersen et al., 2009).

**Potential Moderators: Park Area and Attractiveness**

Parks in this study refer to green spaces for recreational use, which are accessible to the general public, free of charge. They do not include private or inaccessible spaces such as residential gardens and school grounds. Parks in metropolitan Perth were manually digitized in Geographic Information Systems (GIS) software, ESRI ArcGIS v10.1, by drawing a polygon around the park perimeter using the 2010 orthophotography (aerial imagery) and Perth street directory as guides. Parks > 0.3 ha within a road network distance of 400m, 800m, 1200m, and 1600m from participants' home (neighborhood buffer) were used for the study. Parks ≤ 0.3 ha (i.e., pocket parks) were not included due to the unavailability of audit data. The pedestrian network was not available for this study.

For each neighborhood buffer, three park variables, total area, mean attractiveness score, and attractiveness score of the most attractive park, were examined as potential moderators of the relationships between area-level SES and psychological distress. Total park area (ha) was computed for each neighborhood buffer size for each participant. When a park was intersected by a buffer, its whole area was included in the total area. Attractiveness was measured by assigning a score to the park's features and amenities. In 2010, all parks > 0.3 ha in Perth metropolitan area (n=2525) were audited using the Public Open Space Desktop Audit Tool (POSDAT), a desktop auditing tool developed for capturing park attributes (Edwards et al., 2013). Briefly, nine park attributes (lawn irrigation; walking paths; shade along paths; sporting facilities; being adjacent to

beach/river; water features; bird life; surrounding roads; lighting) were audited using remote sensing techniques (e.g., Google Earth). Each park was given an "attractiveness" score by applying a weight for each attribute, which was developed in a previous study (Giles-Corti et al., 2005). As POSDAT is a desktop audit tool rather than an on-site audit tool, we were unable to measure other potentially relevant attributes such as maintenance (graffiti, vandalism), natural surveillance, and dog-regulation related items (e.g., areas where dogs are permitted on or off-leash). Comparing the results using POSDAT with the on-site audit tool, POST (Public Open Space Tool), an existing instrument on which POSDAT is based, Edwards and colleagues (2013) found a significant correlation (r=0.90) between POSDAT and POST attractiveness scores. The POSDAT items were assessed for inter-rater reliability, with 70% or more agreement for most features assessed (Edwards et al., 2013). Since the attractiveness score was closely correlated with park size (larger parks tend to have more features), we divided the total attractiveness score by the total park size within each buffer in order to obtain mean park attractiveness, which is independent of park size. In addition, the most attractive park was identified for each buffer area, and its attractiveness score was used as another potential moderator. This was included in the study because the presence of a highly attractive local park (with more features) was found to be associated with residents' mental health (Francis et al., 2012), walking for recreation (Sugiyama et al., 2010), and park use (Kaczynski et al., 2008).

**Demographic Variables**

Demographic variables included in the study were: gender; age; education (high school, vocational, college or higher); marital status (single, couple); children in the household (yes, no); employment status (unemployed, employed, other which includes home duties, retired, student); and annual household income (≤AUD$40,000, AUD$40,001–$80,000, >AUD$80,000).

## Statistical Analysis

Multinomial logistic regression analysis was used to examine associations of psychological distress with IRSD, adjusting for gender, age, education, marital status, and having children or not. Models did not adjust for employment status and household income, as they may be influenced by socio-economic disadvantage, thus may be on a causal path between SES and psychological distress. The outcome had three levels, and the exposure was continuous (standardized). The analysis estimated the odds ratios for being in the moderate or high level (compared with the low level) of psychological distress for one standard deviation decline in IRSD. (A lower IRSD score indicates a higher level of disadvantage.) We also examined if park attributes (dichotomized) were associated with psychological distress, adjusting for the same covariates. Interaction terms between each park variable and IRSD were calculated to examine whether park area or attractiveness moderated the relationships of IRSD and psychological distress. When the interaction term was significant, analyses stratified by each of the dichotomized park variables were conducted. All models used cluster-robust standard errors to account for non-independence of observations within CCDs (n=2340). Analyses were conducted using STATA version 12 (StataCorp, College Station, TX). Statistical significance was set at $p < 0.05$, except for interaction terms where $p < 0.1$ was considered significant. This level of significance was used for interaction analyses as they tend to have less power (Twisk, 2006).

## RESULTS

Table 1 shows the characteristics of the study sample. In total, slightly less than three quarters of participants reported low psychological distress. The distribution of psychological distress levels varied by IRSD quartiles as shown in Figure 1 (unadjusted, chi-square: $p < 0.001$). Table 2 shows

park variables for each buffer area and each IRSD quartile. The total park area was larger for participants living in the highest IRSD areas. However, mean attractiveness score tended to be slightly higher in the lowest IRSD areas.

(TABLE 1, TABLE 2, & FIGURE 1 ABOUT HERE)

A significant association was found between psychological distress and IRSD: the odds ratios for being in the moderate and high psychological distress categories were 1.13 (95%CI: 1.06, 1.21; $p < 0.001$) and 1.26 (95%CI: 1.16, 1.36; $p < 0.001$), respectively, for one SD decline in IRSD. None of the dichotomized park variables were significantly associated with psychological distress, after adjusting for the covariates, except for mean attractiveness within the 800m and 1200m buffers. Counterintuitively, higher mean attractiveness was associated with a higher odds of being in the high psychological distress category: 1.19 (95%CI: 1.01, 1.39; $p < 0.05$) for the 800m buffer and 1.18 (95%CI: 1.00, 1.38; $p < 0.05$) for the 1200m buffer.

A significant interaction with IRSD was found for two park attributes: mean attractiveness within the 800m buffer on the moderate level of psychological distress ($p = 0.08$) and highest attractiveness within the 800m buffer on the moderate level of psychological distress ($p = 0.06$). Table 3 shows the results of stratified analyses for these attributes. Lower SES was significantly associated with the higher odds of moderate psychological distress among participants with lower park attractiveness within the 800m buffer (both for mean and highest attractiveness). However, no such disparity in psychological distress (moderate level) was observed for participants with higher park attractiveness within the same buffer.

(TABLE 3 ABOUT HERE)

## DISCUSSION

This study explored whether characteristics of local green space (total area, mean attractiveness, highest attractiveness) within a range of buffers moderate the relationship between area-level SES and residents' psychological distress. As anticipated, we found that residents in lower SES areas were significantly more likely to have higher psychological distress than those in higher SES areas. Building on previous studies (Mitchell and Popham, 2008; Mitchell et al., 2015), we hypothesized first that this relationship would be less pronounced among participants who had larger park area in their neighborhood. Our findings did not support this hypothesis. No significant interaction was found for total park area, suggesting that the association between SES and psychological distress is similar across different levels of park area.

This finding (i.e., no moderation by park area) may be partially due to unmeasured park characteristics, which may be different in low and high SES areas. We found that lower SES areas tended to have parks with higher mean attractiveness scores (Table 2), which in this study focused on the presence of facilities and features. However, other park attributes potentially relevant to mental health (e.g., safety, maintenance) were not measurable using the desktop audit tool. Studies in the US have shown that parks located in lower income areas have more safety concerns (e.g., vandalism) and are perceived less safe than those in high income areas (Cohen et al., 2013; Kamel et al., 2014; Vaughan et al., 2013). The presence of larger green space with such safety concerns may have a negative impact on mental health, as fear of crime is known to be detrimental to residents' mental health (Lorenc et al., 2012; Stafford et al., 2007). One study found that deterioration in residential areas was associated with mental health through fear of

crime and less social contact (Kruger et al., 2007). Local parks that are considered unsafe may also deter residents from walking (Cohen et al., 2012; Foster et al., 2014). These studies suggest that the way local parks affect residents' mental health is complex: while the presence of natural elements may be beneficial, park safety and maintenance-related features are also likely to be important. Further investigation is warranted, as POSDAT precluded measurement of items relevant to park safety, with only one item related to safety included (i.e., lighting).

The findings of the study partially supported our second hypothesis with regard to park quality. We found a significant interaction for mean and highest park attractiveness for the 800m buffer with IRSD on moderate psychological distress. Stratified analyses showed that IRSD was associated with moderate psychological distress only among those who had less attractive parks in their local area (either overall or in terms of the most attractive park). In other words, lower and higher SES neighborhoods with attractive local parks did not differ in the prevalence of moderate-level mental health problem. However, it is difficult to claim based on our findings that socio-economic disparities in mental health may be reduced by improving the quality of local parks. First, the moderation was found only for park attractiveness within the 800m buffer, but not for the other buffers. Second, we did not find associations of higher park attractiveness and a lower level of psychological distress. Indeed, counterintuitively, we found that higher mean attractiveness within the 800m and 1200m buffers was associated with a greater odds of being in the high level of psychological distress. Although the interaction was significant for the moderate level of psychological distress, this finding is still not consistent with the hypothesis. This study highlights the complexity of these relationships and further research is needed to test the hypothesis about park attractiveness, incorporating both positive and negative aspects related to park attractiveness (Foster et al., 2014).

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242 The study found that the quantity and quality of parks were not evenly distributed across different
243 SES areas. In terms of park quantity (area), participants in the highest SES areas had more land
244 allocated to parks than those in the other SES areas. This is contrary to previous studies, which
245 showed better access to parks and open spaces in disadvantaged neighborhoods (Franzini et al.,
246 2010; Pearce et al., 2007; Vaughan et al., 2013). However, in terms of mean park attractiveness,
247 we found that disadvantaged areas tended to have a higher score (more facilities and features)
248 than less disadvantaged areas. Although measures of park attractiveness may not be directly
249 comparable, this finding is consistent with one previous study in which parks in lower SES areas
250 had more facilities and features (Badland et al., 2010) but not with other studies (Crawford et al.,
251 2008; Vaughan et al., 2013).

252

253 Such mixed findings may reflect differences in local government's strategy to allocate resources
254 to diverse recreational facilities: the distribution of parks and their quality across different SES
255 areas may be subject to local-level policy and practice on park development and management.
256 However, they may also reflect study limitations. For example, in this study we used a remote
257 sensing audit tool that precluded a number of park attributes potentially relevant to mental health,
258 such as safety and crime concerns. The desktop audit is a valid and cost-effective method to
259 assess park facilities and features. However, it was not able to capture the presence of vandalism
260 or anti-social behavior, which was included in the on-site auditing (Edwards et al., 2013). Given
261 that the presence of park disorder has been shown to limit participation in recreational walking
262 (Foster et al., 2014), future studies may need to consider how to incorporate crime and disorder
263 data in measuring the quality of public open space.

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This study did not consider surrounding environment conditions such as green elements existing outside parks (e.g., private gardens, street trees) and land use, which may also be related to residents' mental health. Indeed, de Vries et al. (2013) found that street-level greenery was associated with mental health, and this association was mediated by stress and social cohesion rather than by physical activity. This suggests that local green space may not have to be used "actively" to affect residents' mental health. Easily accessible green elements that help people to relax or encourage them to interact with neighbors may be also beneficial to their mental health (Lachowycz and Jones, 2013). The presence of such greenery close from home needs to be assessed in future studies to accurately identify the impact of overall local greenness on socio-economic inequalities in mental health.

This study has other limitations. The park audits were conducted in 2010, which was after the data collection from participants (2005–09). Although most parks features do not change in a short term, some parks may have been renovated or degraded during the study period. Pedestrian-only routes, which would influence buffer size and access to parks (Chin et al., 2008), were not available in this study. Most park attributes (area and attractiveness) were not directly associated with psychological distress in this study. This is not consistent with previous studies in which the presence of more green space was found related to lower levels of perceived and objectively-measured stress (Fan et al., 2011; Roe et al., 2013). The study did not measure participants' use of or visits to green space, which could have shed further light on the role of green space in socio-economic inequality in mental health. In addition, the cross-sectional study design limits causal inferences being drawn. Lastly, this study was conducted in the metropolitan area of Perth, Australia, and the findings may not be generalizable to other localities. The strengths of the study include a large sample size and the use of the quality measure of parks as well as the quantity

measure.

In conclusion, our study confirmed that significant mental health disparities existed between lower and higher SES areas. These disparities were not moderated by park area: psychological distress was associated with SES regardless of levels of park area. The study could not confirm the role of park attractiveness in socio-economic inequalities in mental health. While there was some evidence suggesting moderation (lower SES associated with higher psychological distress only in areas with lower park attractiveness), park attractiveness itself was not associated with mental health in the expected direction. Hence, it is unclear whether enhancing parks in low SES areas would reduce mental health inequalities. Further studies examining safety and maintenance features of local parks and street-level greenery are needed to assess whether well-maintained greener local environments can mitigate socio-economic related mental health inequalities.

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## TABLES

**Table 1**. Characteristics of the study sample (N=7034)

| | | |
|---|---|---|
| Mean age (sd) | | 44.4 (13.3) |
| Gender (%) | Women | 59.4 |
| Education (%) | High school | 35.6 |
| | Vocational | 37.5 |
| | College or higher | 26.9 |
| Marital status (%) | Couple | 65.5 |
| Having children (%) | Yes | 46.9 |
| Employment status (%) | Employed | 67.4 |
| | Unemployed | 5.1 |
| | Other [a] | 20.2 |
| | Missing | 7.2 |
| Annual Income (%) | ≤$40k | 20.2 |
| | $40k-$80k | 33.5 |
| | >$80k | 36.2 |
| | Missing | 10.1 |
| Psychological distress (K10) (%) | High | 9.7 |
| | Moderate | 17.7 |
| | Low | 72.6 |

[a] Home duties, retired, student

**Table 2**. Mean (sd) of total park area, mean park attractiveness, and highest park attractiveness score within 400m, 800m, 1200m, and 1600m of participant's home by quartiles of IRSD [a]

| | Total | IRSD [a] (Area-level SES) | | | | |
|---|---|---|---|---|---|---|
| | | Lowest | Second | Third | Highest | p [b] |
| Parks within 400m | | | | | | |
| Total area, ha | 3.7 (9.9) | 3.4 (6.7) | 2.9 (5.6) | 3.5 (10.1) | 5.0 (14.0) | <0.001 |
| Mean attractiveness | 14.9 (22.0) | 17.9 (25.1) | 14.6 (22.1) | 14.3 (21.0) | 13.1 (19.9) | <0.001 |
| Highest attractiveness | 26.1 (23.3) | 27.8 (21.9) | 24.8 (22.9) | 25.0 (23.4) | 26.8 (24.5) | <0.001 |
| Parks within 800m | | | | | | |
| Total area, ha | 10.3 (16.7) | 9.3 (12.6) | 9.3 (13.3) | 9.5 (16.7) | 12.7 (21.7) | <0.001 |
| Mean attractiveness | 16.4 (16.6) | 18.4 (18.5) | 16.8 (17.2) | 15.8 (15.0) | 14.9 (15.8) | <0.001 |
| Highest attractiveness | 42.9 (19.5) | 44.3 (16.6) | 43.0 (18.7) | 41.3 (20.7) | 43.0 (21.1) | <0.001 |
| Parks within 1200m | | | | | | |
| Total area, ha | 19.5 (23.5) | 18.1 (20.1) | 18.1 (19.8) | 18.5 (23.7) | 22.8 (28.3) | <0.001 |
| Mean attractiveness | 14.8 (11.7) | 16.3 (12.6) | 14.7 (11.0) | 14.7 (11.2) | 13.9 (11.8) | <0.001 |
| Highest attractiveness | 50.3 (16.2) | 50.9 (12.8) | 50.9 (15.2) | 49.2 (17.4) | 50.4 (18.2) | <0.01 |
| Parks within 1600m | | | | | | |
| Total area, ha | 30.8 (30.1) | 29.5 (26.3) | 28.5 (24.3) | 29.6 (31.9) | 35.3 (35.2) | <0.001 |
| Mean attractiveness | 14.0 (9.1) | 15.0 (9.6) | 13.7 (7.7) | 14.3 (9.7) | 13.0 (9.2) | <0.001 |
| Highest attractiveness | 54.1 (15.0) | 54.6 (11.4) | 54.6 (13.6) | 52.7 (16.2) | 54.6 (17.3) | <0.001 |

[a] Index of Relative Socio-economic Disadvantage
[b] one-way ANOVA

**Table 3.** Odds ratios (95%CI) for being in the moderate or high psychological distress level (compared with the low level) per one SD decline in IRSD[1]: stratified analyses

| | | Psychological distress level | |
|---|---|---|---|
| | | Moderate | High |
| Mean park attractiveness within the 800m buffer | Lower | 1.19 (1.09, 1.30)*** | 1.31 (1.17, 1.47)*** |
| | Higher | 1.08 (0.98, 1.17) | 1.20 (1.07, 1.34)** |
| Highest park attractiveness within the 800m buffer | Lower | 1.22 (1.11, 1.35)*** | 1.30 (1.15, 1.47)*** |
| | Higher | 1.07 (0.99, 1.16) | 1.23 (1.11, 1.36)*** |

** $p < 0.01$, *** $p < 0.001$

All odds ratios adjusted for age, gender, marital status, having children or not, and corrected for clustering.

[1] Index of Relative Socio-economic Disadvantage (lower values correspond to higher levels of disadvantage)

**FIGURE**

**Figure 1.** Proportions (unadjusted) of low, moderate, and high levels of psychological distress according to quartiles of IRSD (Index of Relative Socio-economic Disadvantage, lower values correspond to higher levels of disadvantage)