Connection to nature and time spent in gardens predicts social cohesion

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Abstract

A person's health and wellbeing are contingent on the amount of social support that they receive. Similarly, experiencing nature has been shown to improve people's health and wellbeing. However, we do not know how relationships between social cohesion, nature experiences and nature connection could interrelate and vary across different types of urban green spaces, and in non-Westernised cultures. We conducted a study on 1,249 residents in Singapore, a tropical city-state, and measured three dimensions of social cohesion (i.e. general social cohesion; trust and sense of community; and social interactions), various types of nature experiences (i.e. amount of green space around one's residence; frequency and duration of urban green space visits; frequency and duration of visits to gardens), and three dimensions of one's connection to nature: self-identity with nature, desire to experience nature, and environmental concern (using the nature relatedness scale). We found that people who strongly identify with nature, who enjoy being in nature, and who had more frequent gardens visits were more likely to have a stronger sense of social cohesion across two dimensions. However, those with stronger environmental concern reported an overall weaker

sense of social cohesion, possibly due to the perception that society's contributions to conserve environmental problems was insufficient. Further, people who gardened more frequently were also more likely to visit green spaces, self-identify with nature and exhibit a stronger desire to experience nature. We propose that strategies targeted at encouraging people to engage in nature-related, collaborative activities at the local community level, such as spending time in local gardens, will increase urban residents' daily nature experiences and its associated benefits such as improving social cohesion.

Keywords: social cohesion, nature-based solutions, urbanization, green space, urban planning, nature relatedness, connection

Introduction

The social environment plays an essential role in the context of place, health and wellbeing. Social cohesion has been used as a key construct to characterise the social environment, and often refers to interpersonal dynamics and/or an approach used to assess quality of life (Berger-Schmitt, 2002; Comstock et al., 2010; Schiefer & van der Noll, 2017). Social cohesion is often associated with positive social interactions that involve feelings of trust, belonging and acceptance (Forrest & Kearns, 2001; Hartig et al., 2014), and connectedness (Berger-Schmitt, 2002; Carpiano, 2006; Comstock et al., 2010; Hartig et al., 2014; Schiefer & van der Noll, 2017). A positive social environment can result in health and wellbeing benefits. For example, countries with high levels of social cohesion and inclusion tend to have people with greater life satisfaction (Delhey & Dragolov, 2016), and more positive attitudes about their health across all levels of society (Chuang et al., 2013). However, social and environmental stressors associated with urban living, such as greater social isolation and reduced opportunities to experience nature in cities, can increase the vulnerability of urban residents to poor health (Lederbogen et al., 2011). Modern, urban lifestyles frequently involve more time spent indoors, greater sedentary behaviour, and less frequent social interactions and integration (Forrest & Kearns, 2001; Macias, 2008; Ng & Popkin, 2012; Hartig & Kahn, 2016). Compared to rural areas, nature in cities may be reduced, with lower species richness (Goddard et al., 2010). As such, a decline in opportunities to experience nature in cities may also reduce opportunities for social engagement and the strengthening of social cohesion. This is particularly pertinent during times of crisis, such as the ongoing COVID-19 disease pandemic which necessitates social distancing and isolation as two major preventative efforts to reduce spread of the virus (Centres for Disease Control and Prevention, 2020).

Some studies have explored the direct contributions of urban green spaces to social capital, because the knowledge can inform the development of strategies that improve urban health (Kondo et al., 2015), such as using urban green spaces to bring people together to increase social interactions and strengthen social cohesion. Urban green spaces encompass areas with grass, trees and/or shrubs, such as parks and greenways (Dinnie et al., 2013; Dennis & James, 2016), and can be common areas where people gather for recreation, leisure, and social purposes. As such, urban green spaces are likely to support and influence social health in urban areas through different pathways. First, green spaces are where people can interact with

each other through a wide range of activities and behaviours, thus increasing social contacts and social cohesion (Maas et at., 2009; Hartig & Kahn, 2016) in ways that may not occur in other settings. Studies have shown that social cohesion and social activities are positively related to the presence and quality of urban green spaces such as parks and forests (Sullivan et al., 2004; Cattell et al., 2008; Kabisch et al., 2015; Jennings et al., 2016), while low social support and greater loneliness were associated with a lack of green spaces (Maas et al., 2009; de Vries et al., 2013). Second, green spaces promote a general sense of community through strengthening people's emotional attachment to the neighbourhood, fostering a strong community identity (i.e. sense of belonging to a particular place; Prezza et al., 2001). Park quantity consistently predicts wellbeing of communities (Larson et al., 2016), while the proximity to, and quality of, parks are positively associated with a strong sense of community (Francis et al., 2012) – possibly because green spaces provide a sense of stability in the context of dynamic, everchanging urban landscapes (Özgüner, 2011; Egerer et al., 2019).

Some studies have shown that the level of engagement within a green space varies in response to the qualities of the green space (e.g. amenities present), the intended use (e.g. for recreation and leisure), and the area's general social context. Some characteristics of the built environment and amenities within or near urban green spaces that have promoted social interactions include: park design (e.g. an open design encourages active recreational activities; Peters et al., 2010), availability of shaded areas for relaxation (Peters et al., 2010), presence of playgrounds (Bennet et at., 2012) and sidewalks (Holtan et al., 2015), and transport options to access green spaces (Ward Thompson et al., 2016). However, other studies have also illustrated that a person's connection to nature is a key determinant of the quantity and quality of nature experiences that they receive (Cox et al., 2017; Oh et al., 2020). A person's connection to nature is a multidimensional concept that involves their personal affiliation with, worldview of, and physical enjoyment of nature (Nisbet et al., 2009). It draws upon the biophilia hypothesis, which suggests that humans have an innate need to connect with nature (Wilson, 1984). Stronger connections between individuals often strengthen aspects of social cohesion (e.g. empathy and willingness to help; Cialdini et al., 1997), while stronger connections to nature have been coupled with stronger social cohesion in people (Weinstein et al., 2015).

This said, prior studies on the relationships between green space availability and social cohesion have predominantly been conducted in temperate countries (e.g. Coombes et al., 2010; Weinstein et al., 2015; van den Berg et al., 2019), and these may vary under tropical

settings with starkly different climatic, biodiversity and cultural conditions. Tropical cities present higher temperatures and humidity which may influence the type, and duration of activities conducted in green spaces (Heng & Chow, 2019). Compared to temperate settings, they are generally also more biodiverse. Indeed, unlike studies conducted in temperate regions where biodiversity strongly predicts wellbeing obtained from time spent in green spaces (Shanahan et al., 2016), other factors such as a person's connection with nature have been found to be more influential in tropical settings (Oh et al., 2021b). Moreover, urban planning in tropical countries can be quite different to temperate countries with urban sprawling approaches, shaping people's interactions with green spaces markedly (Oh et al., 2021).

A combined consideration of how people's daily experiences of nature and connection to nature could enhance social cohesion and the benefits that it confers remains unexplored. Specifically, we do not know how the relationships between social cohesion and nature experiences and nature connection vary across different types of urban green space and their functions for the community (e.g. physical exercise in public parks versus gardening in private/community gardens). Here, we report the results of an investigation of whether measures of social cohesion varied across different types of green spaces and emotional connection to nature in tropical Singapore. We did this by delivering a national online survey to measure (i) three dimensions of social cohesion (i.e. general social cohesion; trust and sense of community; and social interactions; Bullen & Onyx, 1998, Sampson et al., 1999); (ii) green space availability (i.e. amount of green space surrounding one's residence); (iii) the frequency and duration of public park visits; (iv) the frequency and duration of private garden visits; and (v) three dimensions underpinning one's connection to nature (Nisbet et al., 2009). We subsequently also investigated predictors associated with frequency of garden visits as that was a consistent and significant predictor of all three measures of social cohesion. We hypothesise that all three dimensions of social cohesion are associated with changes in frequency of garden visits, but not green space availability.

We conducted our study in Singapore, a highly urbanised and densely populated tropical city-state. With more than 61% of the country covered in different types of greenery (Gaw et al., 2019), and featuring approximately 423 parks (National Parks Board, 2019), Singapore ranks among the top cities in the provision of urban green spaces (Richards et al., 2017). Singapore's greening policies aim to place 80% of residents within a 10-minute walk to a park (Ministry of the Environment and Water Resources and Ministry of National

Development, 2014). As Singapore represents a highly compact urban development, the majority of residents reside in high-rise apartments (Singapore Department of Statistics, 2019), with limited access to private gardens, yards or balconies, and only 5% of the population reside in houses with some access to a private garden or yard. The most common forms of gardening therefore occur through potted plants that line the building corridors, and community gardens where local residents cultivate fruits and vegetables in shared neighbourhood spaces (Shan, 2019). To date, there are more than 1,300 community gardens in Singapore that provide residents opportunities to get closer to nature (Shan, 2019).

Methods

Survey procedure and participants – We delivered an urban lifestyle survey across a 1-month window in 2019. The survey was deployed through a market research company, and in accordance with both the University of Queensland Institutional Human Research Ethics Approval (project number 2018001775) and the Institutional Review Board at the National University of Singapore (project reference S-18-344).

The survey was delivered to a stratified subset of 1,519 Singapore residents (18 years and above) voluntarily enrolled in the survey database of the market research company. Respondents were stratified according to age (50% aged 18 to < 45 years and 50% aged 45 – 75 years), gender (50% males and 50% females), income (four quartiles), ethnicity (i.e. 70% Chinese; 15% Malay: 7% Indian and 8% Others), and greenspace coverage surrounding current residence (four quartiles) to approximate the national population (see Table S1, Supporting Information for the demographic distribution of the survey data). All respondents provided informed consent through a tick-box at the beginning of the online survey.

Social cohesion – We assessed respondents' perceptions of social cohesion across three dimensions: general social cohesion (Bullen & Onyx, 1998), trust and sense of community (Sampson et al., 1999) and social interactions (Sampson et al., 1999; Table S2). Here, social cohesion refers to shared norms and values, the existence of positive and friendly relationships, and feelings of acceptance and belonging (Forrest & Kearns, 2001), and is characteristic more of neighbourhoods than of individuals (Baum et al., 2009). Respondents were invited to rate a total of 17 statements using either a 4- or 5-point Likert scale (see Table S2 for full list of options). An aggregation of the responses for each dimension provided a

measure of respondents' social cohesion perceptions, with higher scores indicating greater social cohesion, stronger trust and sense of community, and more frequent social interactions.

Green space availability – We invited respondents to provide the postal code of (or the nearest street to) their place of residence. Those who provided the nearest street (n = 13) were excluded from further analyses. We then used the Google API service with the *geocode* function in the R package *ggmap* (Kahle & Wickham, 2013) to assign GPS coordinates to each postal code, before overlaying them onto a Singapore land use map (Gaw et al., 2019). Radial distances of 250 m, 500 m, 1 km, and 1.5 km were used to create buffers around each respondent's place of residence (as indicated by the GPS coordinates) to measure the proportion of green space surrounding each respondent's place of residence. Green space comprised up to five different land use types including: unmanaged vegetation, managed vegetation, mangrove forests, freshwater swamp forests, and freshwater marsh (Gaw et al., 2019). We chose four different buffer sizes as (i) the distance within which green space availability provided beneficial outcomes is not well understood; and (ii) it allowed us to capture the interplay between longer travel durations and shorter visit frequencies (Browning & Lee, 2017). For example, the larger 1.5 km buffer entailed longer travel durations, which has been associated with a decline in visitation frequencies (Browning & Lee, 2017).

Frequency and duration of green space visits – Respondents first reported how often they visit or pass through outdoor green spaces for any reason by choosing from nine options (i.e. 6–7 days a week; 3–5 days a week; 2–3 days a week; once a week; 2–3 times a month; once a month; once every three months; once a year; never). The option for those who visited greenspaces 3 days a week was intentionally non-exclusive, to allow respondents the flexibility of indicating whether they used greenspaces 3 days a week and were generally more inclined towards more, or fewer, visits. Outdoor green spaces were introduced as: "For example, this includes beaches, parks and nature reserves, rooftop gardens, golf courses, and gardens." Responses were converted to a continuous variable by using the bottom-point of each category, and standardised to the frequency of visits per week (e.g. 6–7 days a week = 6; 3–5 days a week = 3; 2–3 times a month = 0.5 etc.). Respondents also reported on the total duration (number of hours) spent in outdoor green spaces in the previous week (Table S2). We chose this short and recent reference time frame to improve recall accuracy (Schwarz & Oyserman, 2001), and to minimise correlation with frequency of green space visitation.

Frequency and duration of garden visits – Respondents first reported how often they spend more than 10 minutes in a garden by choosing from nine options (i.e. 6–7 days a week; 3–5 days a week; 2–3 days a week; once a week; 2–3 times a month; once a month; once every three months; once a year; not applicable [I do not have my own garden, potted plants along my corridor and community garden]). Gardens were introduced as: "This includes your own garden, a community garden, or the potted plants along your corridor." Responses were converted to a continuous variable by using the bottom-point of each category (e.g. 6–7 days a week = 6; 3–5 days a week = 3 etc.). Respondents who indicated "Not applicable" were excluded from subsequent analyses. Respondents also reported on the total duration (number of hours) spent in garden(s) in the previous week (Table S2).

Nature relatedness – We measured respondents' nature orientation using the Nature Relatedness Scale (Nisbet et al., 2009). The scale differentiates between groups of individuals who are nature enthusiasts, and those who engage with nature to a lesser extent (Nisbet et al., 2009). Respondents were invited to rate a set of 21 statements using a 5-point Likert scale ranging from 1 (disagree strongly) to 5 (agree strongly); 8 statements were reverse scored (Table S2). The scale comprises three subscales: *NR-Self* (*affective*) assesses how strongly an individual identifies with nature; *NR-Perspective* (*cognitive*) assesses an individual's worldview of nature-related issues and is manifested through attitudes and behaviour; and *NR-Experience* (*experiential*) reflects an individual's physical familiarity with, and enjoyment of, nature. An aggregation of the responses for each subscale (as per Nisbet et al., 2009) provides a measure of an individual's relationship with nature, with a higher score indicating a stronger connection.

Covariates – We also collected socio-demographic variables including age, gender, ethnicity, personal income, occupation, duration of residence in the current dwelling, housing type, and number of children and number of adults in the family, as these have been associated with social cohesion outcomes in previous studies (Dekker & Bolt, 2005; Bailey et al., 2012; Kilroy, 2012; Hochschild, 2015; Weinstein et al., 2015; Shanahan et al., 2016), and to control for potential confounders during analyses (see Table S2 for the questionnaire).

Statistical analyses – We conducted all analyses in R version 3.6.1 (R Core Team, 2019), with a final dataset of 1,249 respondents after excluding incomplete or unrealistic responses (e.g. spending 168 hours a week on green space visits). We conducted two sets of analyses. The first set investigated predictors of social cohesion, wherein either general social

cohesion, trust and sense of community, or social interactions was the response variable. The second set investigated predictors of garden engagement, and frequency or duration of garden visits was specified as the response variable.

Our first set of analyses examined the relationships between the social cohesion response variables, and predictors relating to nature availability, engagement with gardens and nature relatedness. We constructed three groups of generalised linear regression models – each group was assigned one of the three social cohesion scores as the response variable, but used the same set of predictor variables, namely, proportion of green spaces within the 250 m and 1.5 km buffer, frequency and duration of green space visits, frequency and duration of garden visits, the three nature relatedness sub-scales, and socio-demographic covariates. We only used green space availability within the 250 m and 1.5 km buffers as predictors because an assessment of multicollinearity (prior to analyses) using the *vif* function from the *usdm* package (Naimi, 2015) indicated that green space availability within the 250 m, 500 m, 1 km, and 1.5 km buffers were collinear (VIF > 3). As such, we retained only green space availability within the 250 m and 1.5 km buffers as predictors after conducting stepwise model selection. We also specified a quasi-Poisson error distribution to account for overdispersion, and applied an information theoretic approach (Zuur et al., 2009) by generating 28 models (per group) with different possible combinations of predictor variables (see Table S4 for a summary of models considered). For each group, we selected models with the lowest quasi Akaike information criterion (QAIC), and conducted model averaging using the *MuMIn* package (Barton, 2015) for models sharing similar QAIC (delta QAIC<2).

As it was possible that a different statistical treatment of the response variables might result in a different set of significant predictors, we then conducted an additional analysis using a multivariate regression technique that considered all three social cohesion response variables (per respondent) simultaneously in one model. Compared to the single-cohesion-scale analysis where each model only had one social cohesion response variable, this multivariate regression analysis allowed us to account for the interdependence between the three social cohesion response variables (Wang et al., 2012). We used the *manylm* function (*mvabund* package; Wang et al., 2012), and specified the response variable as a matrix of scores (i.e. each respondent had three separate averaged scores of the items corresponding to each social cohesion scale), while the predictor variables remained unchanged. Stepwise model simplification was used to obtain the most parsimonious model. We also re-analysed the three groups of generalised linear regression models by recoding two variables: frequency of green

space and garden visits. Specifically, responses from the categories "3–5 days a week" and "2–3 days a week" were combined into one category "2 – 5 days a week", and converted into a standardised, continuous variable by using the bottom-point of that category (as per above). We did so as the non-exclusive options of both variables might affect the models' results. As the top models and parameter estimates in this re-analysis were highly similar to the original analysis (which we report here), the results from this re-analysis are reported in the supporting information (see Tables S9 – S13).

We then conducted a second set of analyses to identify predictors associated with spending time in gardens as our first set of analyses identified that the frequency of garden visits significantly predicted social cohesion. We constructed a generalised linear regression model with a binomial error distribution wherein frequency of garden visits was specified as the response variable. The predictor variables were: proportion of green spaces within the 250 m and 1.5 km buffer, frequency and duration of green space visits, the three nature-relatedness sub-scales, and socio-demographic covariates. We then applied an information theoretic approach (Zuur et al., 2009) by generating 23 models (see supplementary information for list of models) related to our hypotheses. The best-fitting model had the lowest AIC (or averaged models with delta AIC<2). While we report the model-averaged confidence intervals, we would like to caution readers that they may suffer from post-interference problems (Kabaila, 2009).

Results

Predictors of social cohesion – Outputs from the single-cohesion-scale analyses indicated that two social cohesion scores (i.e. SC_Interaction; SC_Trust) exhibited a positive correlation with frequency of garden visits (Figure 1; see Table S5 for exact numeric coefficients), but not with duration of garden visits, frequency and duration of green space visits or availability of green spaces (Figure 1; Table S5). However, the effect size of frequency of garden visits when compared to some other socio-economic factors could be small. To illustrate, the effect size for one unit increase in frequency of garden visits is 0.031 while that of housetype "private, small" (compared to the baseline "public, small") is 0.143 for SC_Interaction (Table S5). When we apply a back-transformation, an increase in the frequency of garden visits from none to daily visits in a given week (i.e. change in frequency from 0 to 7) will increase the SC_Interaction score by 3.32, which is approximately a quarter

of the 14.7 increase expected when living in a private, small house. We also found a positive correlation between all three social cohesion scores with NR-Self and NR-Experience, indicating that people who strongly identify with nature, and who are familiar with, and enjoy, nature, reported stronger social cohesion (Figure 1; Table S5). Conversely, we found a negative correlation between two social cohesion scores (i.e. SC_Interaction; SC_General) with NR-Perspective (Figure 1; Table S5), indicating that people with greater awareness of environmental issues reported weaker social cohesion within their communities. We report the results from the additional multivariate regression analyses in the supplementary material (Table S6) as they were generally consistent with that from the single-cohesion-scale analysis (Figure 1; Table S5).

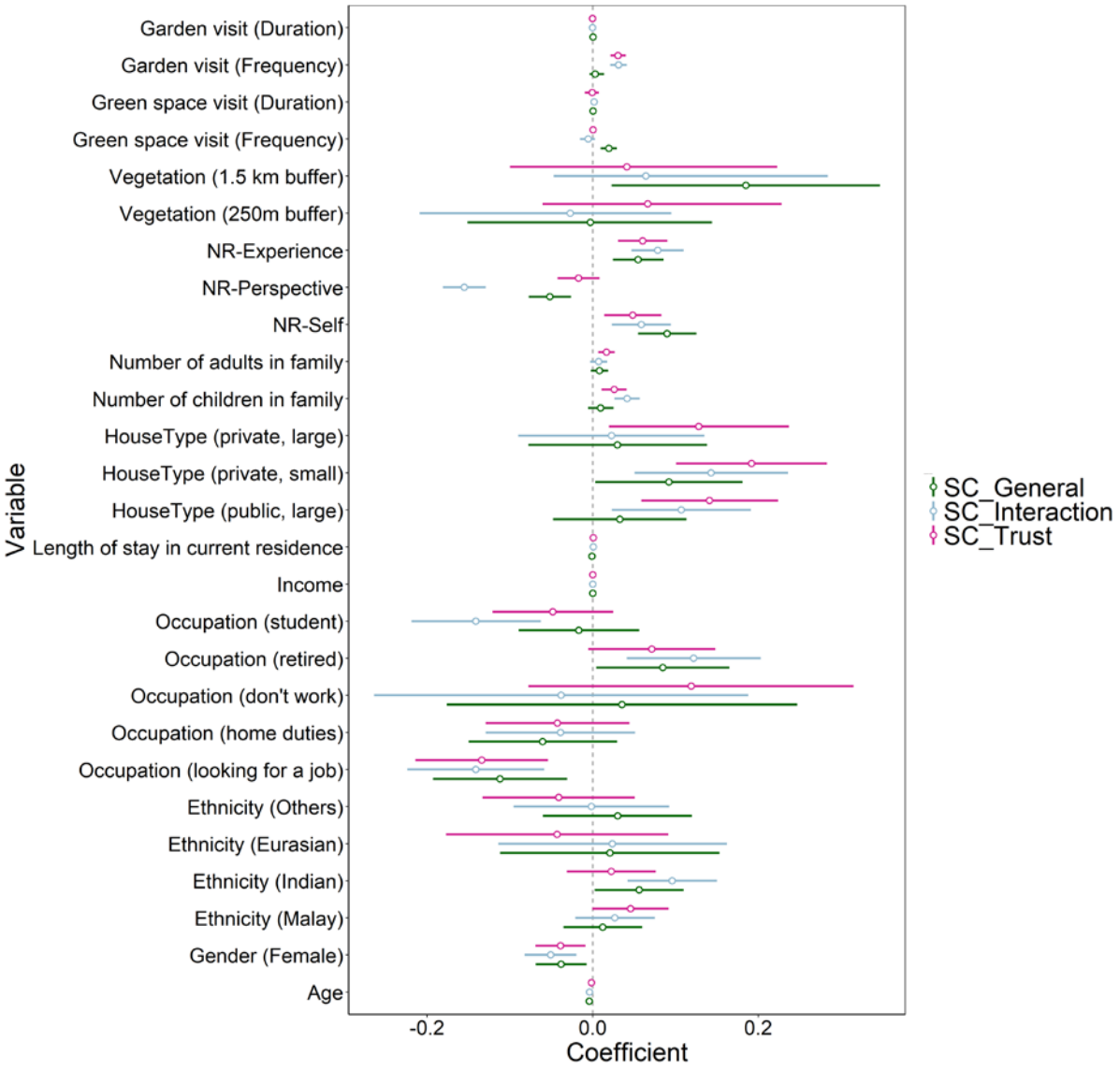

Figure 1: The model-averaged coefficients and confidence intervals of each factor on each of the three social cohesion measurements (from the single-cohesion-scale analyses): general social cohesion (SC_General), social interactions (SC_Interaction), and trust and sense of

community (SC_Trust). The model-averaged coefficients and confidence intervals for categorical factors are presented relative to a comparative base factor level (Ethnicity: Chinese; Occupation: Working; Housetype: public, small). Please refer to Table S5 (supplementary material) for numeric values.

Predictors of garden use – We found a positive correlation between frequency and duration of green space visits with frequency of garden visits (Figure 2; Table S8). Similarly, only NR-Self and NR-Experience positively predicted frequency of garden visits (Figure 2; Table S8). We found no evidence of a significant relationship between measures of nature availability (within 250m and 1.5km from residence) with the frequency of garden visits (Figure 2; Table S8).

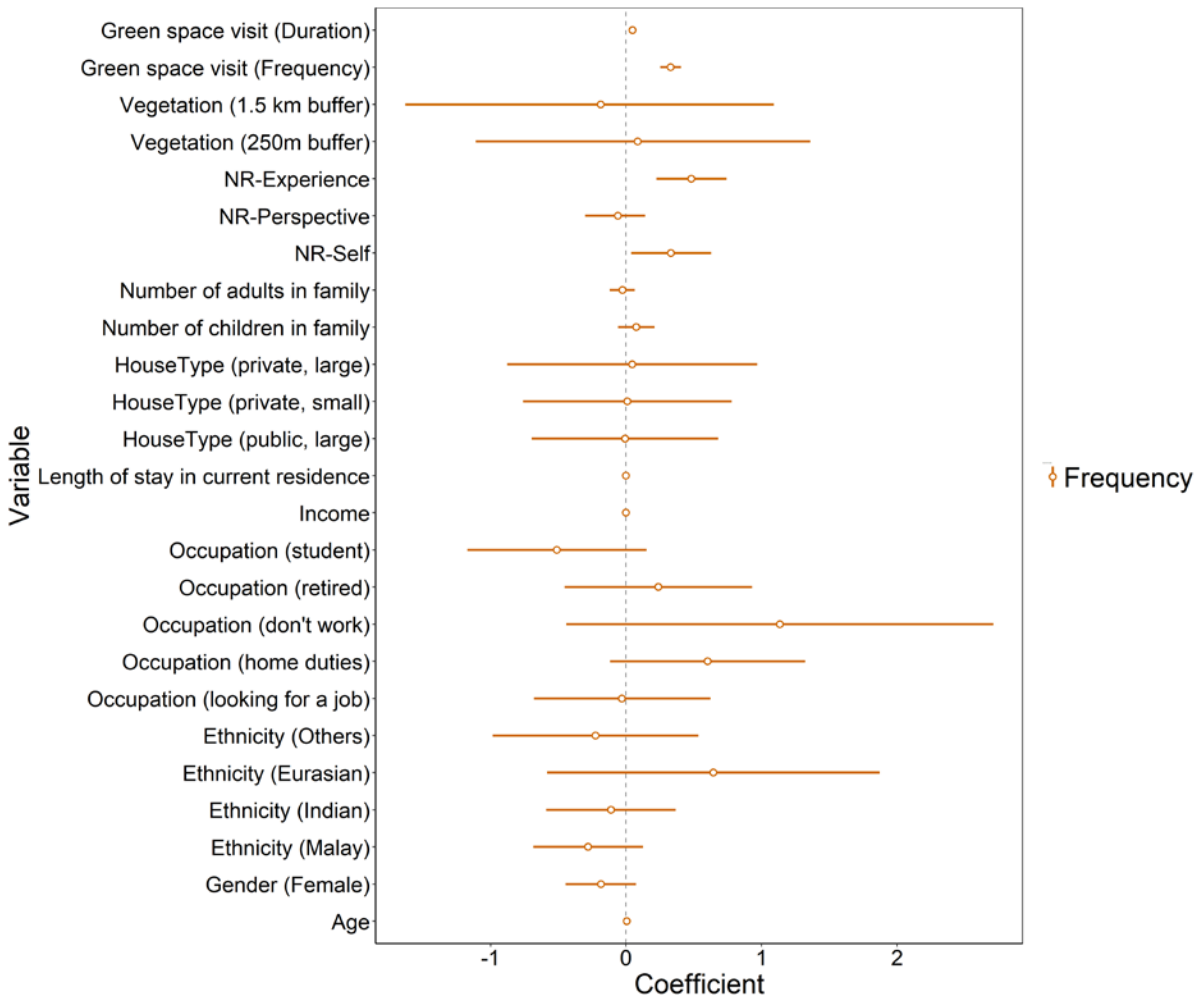

Figure 2: The model-averaged coefficients and confidence intervals of each factor on the frequency of garden visits. The model-averaged coefficients and confidence intervals for categorical factors are presented relative to a comparative base factor level (Ethnicity:

Chinese; Occupation: Working; Housetype: public, small). Please refer to Table S8 (supplementary material) for numeric values.

Discussion

We found that people who had a higher frequency of garden visits, identified more strongly with nature (NR-Self) and had a greater physical familiarity with, and enjoyment of, nature (NR-Experience) were more likely to feel a stronger sense of social cohesion (across two dimensions). In contrast, those who had a stronger awareness of nature-related issues (NR-Perspective) were generally associated with a weaker sense of social cohesion.

Garden visits and social cohesion

Community gardens in shared, public spaces in Singapore are more prevalent than private gardens as the bulk of residents reside in high-rise buildings, precluding any access to private gardens. Also, community gardens support very specific activities related to gardening, which are different to other types of urban green spaces such as public parks, which host a wider variety of activities that may be less suited for social interactions (e.g. jogging). Our finding of a positive relationship between social cohesion and garden use suggest that it is the type of contact with nature that underpins a strong sense of belonging, connectedness and inclusion within the local community. The Singapore context is unique in that gardens and potted plants are generally community-shared spaces instead of private gardens (Oh et al., 2018). Gardens, and the gardening activities that they imbue, could therefore represent an essential space that increases positive social interactions between people (Soga et al., 2017). Gardening activities help bring people out of their private homes into community spaces, thereby encouraging them to interact and engage in cooperative, reciprocal and altruistic behaviours that are likely to promote social cohesion, such as the exchange of plants and harvest (Veen et al., 2016; Soga et al., 2017). While our results are consistent with previous research (Kingsley & Townsend, 2006; Comstock et al., 2010; Camps-Calvet et al., 2015), the correlational nature of this study challenged our abilities to ascertain the presence and direction of the causal relationship(s) between contact with nature and social cohesion outcomes. In this study, we assumed that the direction of causality led from contact with nature to social cohesion outcomes. Yet, other possible, non-mutually exclusive pathways may exist. For example, it could be that socially cohesive people are more disposed to gardening and that is driving this positive relationship (Veen et al., 2016). Alternatively, it

may be the intrinsically cooperative nature of this leisure activity (i.e. gardening) that is particularly suited for strengthening social cohesion since the activity frequently occurs in the local, communal neighbourhood and brings together people sharing the same (gardening) interest. As such, future studies might involve a longitudinal study design and investigate whether changes in contact with nature and social cohesion outcomes (if any) represent a short-term fluctuation or an emerging long-term trend. Conversely, we did not detect a significant relationship between green space availability and green space visits on social cohesion measures, unlike that in other studies (Maas et al., 2009; de Vries et al., 2013; Dadvand et al., 2016) – possibly because urban green spaces are equitably distributed across the country (Nghiem et al., 2021), and nature is pervasive all year round because of the tropical setting (compared to temperate countries that have a strong seasonality effect).

Our findings suggest that an active engagement in nature activities at the community level, such as spending time in community gardens or gardening could be an effective method to increase social interactions in communities to strengthen social cohesion. However, practitioners who strive to strengthen social cohesion should also ensure that these nature-based activities require some form of cooperation and collaboration, as that might be a key pathway through which contact with nature strengthens social cohesion. The design of urban landscapes to have shared green spaces for local residents to spend time outdoors, in nature, and with each other would be a great leverage platform as contact with nature also benefits people's health and wellbeing (Irvine et al., 2021). This is particularly relevant in rapidly urbanising cities, and their increasing vulnerability to additional pressures such as climate change and the urban heat island effect (Lin et al., 2021). Such green spaces would not only provide urban residents with daily opportunities to experience nature (and therefore acquire physical and social health benefits), it would also help improve people's thermal comfort levels and mitigate the larger urban heat island effect.

Nature relatedness and social cohesion

Our results found contrasting relationships between different components of nature-relatedness on social cohesion, even after controlling for the socio-economic standing of individuals. People who identified more strongly with nature (NR-Self) and have a greater physical familiarity with, and enjoyment of, nature (NR-Experience) felt a stronger sense of social cohesion, highlighting that the connectedness between people and nature shares similar qualities to the connectedness between people. Therefore, those who tend to seek greater

contact with nature are also likely to seek contact with other people, or have perceptions of a more cohesive community. Given that social interactions have the capacity to increase happiness, even in introverted individuals (Cabello & Fernandez-Berrocal, 2015), social cohesion might explain why people who are strongly connected to nature also state higher levels of happiness and life satisfaction, and greater subjective wellbeing (Nisbet et al., 2011; Capaldi et al., 2014; Pritchard et al., 2020). Specifically, social interactions that happen in a natural environment may enhance subjective wellbeing, or the improved subjective wellbeing from spending time in nature may result in greater willingness to help others and stronger social cohesion. While we cannot determine the direction of causality because of the cross-sectional nature of this study, future research could use qualitative methods (e.g. conduct semi-structured focus group interviews) to explore the directionality of pathways between one's connection to nature and social and subjective health outcomes.

In contrast, people who were more aware of nature-related issues (stronger NR-Perspective) such as the on-going biodiversity crisis perceived a general weaker sense of social cohesion. Perhaps these outcomes are reflective of their stronger cognitive concerns about the negative impacts of humans on the environment. As such a greater awareness of current, global environmental problems might be associated with greater negative emotions, stress and depression (Cunsolo & Ellis, 2018; Hayes & Poland, 2018), more negative perceptions that others are not actively working together to contribute to environmental conservation (Parks et al., 2013) and higher levels of distrust in external control. These individuals also tend to exhibit stronger individualism (rather than collectivism) as they do not conform to social norms or cues on how to behave in environmentally protective ways (Eom et al., 2016; Tam & Chan, 2017). However, these reported relationships may not be generalisable to other populations since the data was acquired from a Singapore population. A future study could be to conduct a cross-cultural replication of this study to understand how it may vary across different populations, particularly those in tropical, non-Western settings.

Green space and garden visitation

We further found that people who visited green spaces more frequently were also more likely to behave in the same way for gardens, mirroring a study conducted in England (de Bell et al., 2020). Self-reinforcing positive feedback loops between nature experiences and spending time in the garden might therefore exist, though we cannot demonstrate causality given the correlational nature of our study. Our findings further highlight that the relationships between

people's connection to nature, green space availability and time spent on garden visits are likely to vary culturally. A study conducted in the United States found that people with a stronger connection to nature are more likely to spend longer in gardens, and exhibit stronger environmentally protective behaviour (Cartwright & Mitten, 2017) while connection to nature in this Singapore context predicted the frequency of garden visits. Similarly, a greater availability of green space in Dublin, Ireland correlated with longer durations in gardens (Corrigan, 2011), while we failed to find evidence of this effect in Singapore.

Conclusion

We investigated whether measures of social cohesion varied across different types of green spaces and emotional connection to nature in tropical Singapore, one of the world's most densely populated cities. We found that people who had more frequent garden visits, identified strongly as a part of nature (NR-Self), and enjoyed being in nature (NR-Experience) are those who perceived stronger social cohesion. We did not find any significant relationships between green space availability and green space visits with social cohesion. However, those who spent time visiting urban green spaces were also more likely to spend time in gardens. We propose that a strategy of getting people actively to engage in collaborative and/or cooperative nature-based activities such as gardening will increase urban residents' daily nature experiences and its associated benefits such as improving social cohesion.

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Supplementary Material

Table S1: The distribution of respondents across (n = 1249) the suite of response and predictor variables used in this study. The number of respondents per category are provided for categorial variables, while the mean and standard deviation (SD; in brackets) are provided for continuous variables.

Variable	**n**
Age (years)	
18-25	178
26-35	312
36-45	273
46-55	264
56-65	163
66-75	59
Gender	
Male	628
Female	621
Ethnicity	
Chinese	944
Malay	155
Indian	101
Eurasian	15
Other	34
Occupation	
Working	1019
Not working but looking for job	53
Home duties	42
Don’t work	7
Retired	58
Student	70
Monthly Personal Income (SGD)	
No income	103
< 400	45
400 – 599	36
600 - 799	20
800 - 999	30
1,000 - 1,499	67
1,500-1,999	52
2,000-2,999	152
3,000-3,999	183
4,000-4,999	135
5,000-5,999	118
6,000-6,999	95
7,000-7,999	50
8,000-8,999	64
9,000-9,999	32
>10,000	67

House Type	
HDB* 1 room flat	20
HDB 2-room flat	32
HDB 3-room flat	206
HDB 4-room flat	421
HDB 5-room flat	284
HDB / Government Executive flat	71
Condominium/ Private flat/ Apartment	158
Terrace/ Semi-detached house/ Bungalow	57
Length of stay in current residence (years)	13.69 (10.89)
Number of children in family	0.68 (1.00)
Number of adults in family	2.94 (1.49)
NR-Self	3.55 (0.56)
NR-Perspective	3.39 (0.61)
NR-Experience	3.13 (0.63)
Green space visit (Frequency)	
6-7 days a week	192
3-5 days a week	232
2-3 days a week	255
Once a week	259
2-3 times a month	115
Once a month	78
Once every three months	62
Once a year	29
Never	27
Green space visit (Duration in hours)	3.89 (10.97)
Garden visit (Frequency)	
6-7 days a week	131
3-5 days a week	221
2-3 days a week	263
Once a week	256
2-3 times a month	136
Less than once a month	174
Never	68
Garden visit (Duration in hours)	2.75 (5.39)
Proportion of vegetation in 250 m buffer	0.27 (0.11)
Proportion of vegetation in 1.5km buffer	0.36 (0.09)
Social cohesion (Trust)	14.88 (5.16)
Social cohesion (Interaction)	13.90 (5.04)
Social cohesion (General)	14.35 (4.11)

***** HDB flats are public housing

Table S2. An overview of the survey questions and respective options delivered to respondents. Questions measured the frequency and duration of green space and garden visits, the three nature-relatedness subscales, and the three dimensions of social cohesion.

Survey questions	**Scale/Response options**
Frequency and duration of green space visits	
1. About how often do you usually visit or pass through outdoor greenspaces for any reason?	9 options (6-7 days a week to never)
2. Can you estimate the total time you spent in the outdoor greenspaces in Singapore last week?	Open-ended
Frequency and duration of time spent in gardens	
1. About how often do you usually spend more than 10 minutes in a garden?	8 options (6-7 days a week to never, and "NA" option)
2. Thinking about the last week, about how much time in total did you spend in a garden?	Open-ended
Nature relatedness	5-point scale (strongly disagree to strongly agree)
Subscale 1: NR-Self	
1. My connection to nature and the environment is a part of my spirituality.	
2. My relationship to nature is an important part of who I am.	
3. I feel very connected to all living things and the earth.	
4. I am not separate from nature, but a part of nature.	
5. I always think about how my actions affect the environment.	
6. I am very aware of environmental issues.	
7. I think a lot about the suffering of animals.	
8. Even in the middle of the city, I notice nature around me.	
9. My feelings about nature do not affect how I live my life.	
Subscale 2: NR-Perspective	
10. Humans have the right to use natural resources any way we want.	
11. Conservation is unnecessary because nature is strong enough to recover from any human impact.	
12. Animals, birds and plants should have fewer rights than humans.	
13. Some species are just meant to die out or become extinct.	
14. Nothing I do will change problems in other places on the planet.	
15. The state of non-human species is an indicator of the future for humans.	
Subscale 3: NR-Experience	
16. The thought of being deep in the forest, away from civilisation, is frightening.	
17. My ideal vacation spot would be a remote wilderness area.	
18. I enjoy being outdoors, even in unpleasant weather.	
19. I don't often go out in nature.	
20. I enjoy digging in the soil and getting my hands dirty.	
21. I take notice of wildlife wherever I am.	

Social cohesion	
Subscale: Trust and sense of community	5-point scale (strongly disagree to strongly agree)
1. People in this community are willing to help their neighbours.	
2. This is a close-knit community.	
3. People in this community can be trusted.	
4. People in this community generally don't get along with each other.	
5. People in this community do not share the same values.	
Subscale: Social interactions	4-point scale (never to most of the time)
1. How often do you and people in your community do favours for each other?	
2. When a neighbour is not at home how often do you and other neighbours watch over their property?	
3. How often do you and people in your community ask each other advice about things such as child rearing or job openings?	
4. How often do you and people in your community visit in each other's homes or on the street?	
5. How often do you and people in your community have parties or other get-togethers?	
6. How often do you and people in your community spend leisure time together going out for dinner, to the movies, to a sporting event etc?	
Subscale: General social cohesion	4-point scale (never to most of the time)
1. Do you feel safe walking alone down your street after dark?	
2. Do you feel valued by society?	
3. Do you feel there are opportunities to have a real say on issues that are important to you?	
4. Can you get help from friends, family and neighbours when needed?	
5. Do you help out a local group as a volunteer?	
6. Do you think multiculturalism makes life in your area better?	

Table S3: Pearson correlation matrix between the three social cohesion dimensions. Significance: * $p < 0.05$; * * $p < 0.01$; * * * $p < 0.001$.

	Cohesion (Trust)	**Cohesion (Interactions)**	**Cohesion (General)**
Cohesion (Trust)	1***	0.55***	0.55***
Cohesion (Interactions)	0.55***	1***	0.59***
Cohesion (General)	0.55***	0.59***	1***

Table S4: The QAIC scores for each respective model used in the information theoretic approach that investigated the relationships between each dimension of social cohesion (i.e. general social cohesion; trust and sense of community; and social interactions), and predictors. The top models for each social cohesion dimension were selected based on the QAIC scores and highlighted in bold. QAIC1 represent models with "trust and sense of community" as the response variable; QAIC2 for models with "social interactions" was the response variable; and QAIC3 for models with "general social cohesion" as the response variable.

	Model	**QAIC1**	**QAIC2**	**QAIC3**
	Null model			
1	1	3776.4	4673.0	6435.7
	Full model			
2	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + LengthofStay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	3733.7	4465.7	6249.4
	Model with only socio-demographic variables to control confounding effects			
3	Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation	3761.4	4578.0	6353.4
4	Frequency (Park) + Duration (Park)	3761.5	4642.7	6393.9
5	Frequency (Garden) + Duration (Garden)	3735.6	4619.3	6381.7
6	Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden)	3736.9	4610.3	6372.8
7	Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	**3715.3**	**4442.7**	6240.2
8	NR_Exp	3734.5	4613.3	6338.6
9	NR_Per	3777.8	4611.7	6437.1
10	NR_Self	3744.3	4648.6	6346.9
11	NR_Exp + NR_Per + NR_Self	3731.1	4511.2	6303.5
12	Vege1500 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	3716.7	**4443.7**	**6237.4**
13	Vege1500 + Vege250	3780.2	4676.3	6436.8
14	Vege1500 + Vege250 + Frequency (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	**3716.5**	4446.8	**6238.1**
15	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	3731.8	4463.9	6247.8
16	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Age + Ethnicity + Gender + Housetype +	**3716.3**	**4443.6**	**6237.7**

	Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self			
17	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation	3733.3	4537.1	6301.7
18	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp	3717.7	4521.4	6264.0
19	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per	3719.5	4449.4	6259.6
20	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	3718.2	4445.3	6239.4
21	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Self	3716.9	4523.4	6251.2
22	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Per	3735.0	4482.2	6302.5
23	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Per + NR_Self	3723.0	4457.2	6248.0
24	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Self	3721.6	4533.1	6259.1
25	Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	3728.0	4463.4	6253.1
26	Vege1500 + Vege250 + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	**3714.5**	4445.5	**6237.3**
27	Vege1500 + Vege250 + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	**3716.2**	**4444.3**	**6238.4**
28	Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	**3716.4**	**4444.6**	6241.8

Table S5: The model-averaged coefficients and confidence intervals of each factor on each of the three social cohesion measurements (from the single-cohesion-scale analyses): general social cohesion (SC_General), social interactions (SC_Interaction), and trust and sense of community (SC_Trust). The model-averaged coefficients and confidence intervals for categorical factors are presented relative to a comparative base factor level (Ethnicity: Chinese; Occupation: Working; Housetype: public, small). Please refer to Figure 1 in the main manuscript for a graphical representation of these values.

	SC_General			SC_Interaction			SC_Trust		
Variable	**Coeff.**	**CI2.5**	**CI97.25**	**Coeff.**	**CI2.5**	**CI97.25**	**Coeff.**	**CI2.5**	**CI97.25**
Intercept	**2.316**	**2.156**	**2.476**	**2.618**	**2.456**	**2.780**	**2.150**	**1.990**	**2.311**
Age	-0.004	-0.005	-0.003	-0.004	-0.005	-0.002	-0.001	-0.003	0.000
Gender (Female)	-0.038	-0.069	-0.007	-0.051	-0.082	-0.020	-0.039	-0.069	-0.009
Ethnicity (Malay)	0.012	-0.035	0.060	0.027	-0.021	0.075	0.046	0.000	0.092
Ethnicity (Indian)	0.056	0.002	0.110	0.096	0.042	0.150	0.023	-0.031	0.076
Ethnicity (Eurasian)	0.021	-0.112	0.153	0.024	-0.114	0.162	-0.043	-0.177	0.091
Ethnicity (Others)	0.030	-0.060	0.120	-0.001	-0.095	0.093	-0.041	-0.133	0.051
Occupation (looking for a job)	-0.112	-0.193	-0.031	-0.141	-0.224	-0.059	-0.134	-0.214	-0.054
Occupation (home duties)	-0.060	-0.150	0.030	-0.039	-0.129	0.051	-0.043	-0.129	0.044
Occupation (don't work)	0.035	-0.176	0.247	-0.038	-0.264	0.188	0.119	-0.078	0.315
Occupation (retired)	0.085	0.004	0.165	0.122	0.041	0.203	0.072	-0.005	0.148
Occupation (student)	-0.017	-0.089	0.056	-0.141	-0.219	-0.063	-0.048	-0.121	0.025
Income	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Length of stay in current residence	-0.001	-0.002	0.001	0.001	-0.001	0.002	0.001	-0.001	0.002
HouseType (public, large)	0.033	-0.048	0.113	0.107	0.023	0.191	0.141	0.059	0.224
HouseType (private, small)	0.092	0.003	0.181	0.143	0.051	0.236	0.192	0.101	0.283
HouseType (private, large)	0.030	-0.078	0.138	0.023	-0.090	0.135	0.128	0.020	0.237
Number of children in family	0.010	-0.006	0.025	0.042	0.027	0.057	0.026	0.011	0.041
Number of adults in family	0.008	-0.002	0.019	0.007	-0.003	0.018	0.017	0.007	0.027
NR-Self	0.090	0.055	0.125	0.059	0.023	0.094	0.048	0.014	0.083
NR-Perspective	-0.052	-0.077	-0.026	-0.155	-0.181	-0.129	-0.017	-0.042	0.008
NR-Experience	0.055	0.024	0.086	0.078	0.047	0.110	0.060	0.031	0.090
Vegetation (250m buffer)	-0.003	-0.151	0.144	-0.027	-0.209	0.095	0.067	-0.060	0.228

Vegetation (1.5 km buffer)	0.185	0.023	0.347	0.064	-0.047	0.284	0.041	-0.100	0.223
Green space visit (Frequency)	0.019	0.010	0.029	-0.005	-0.015	0.003	0.000	-0.001	0.002
Green space visit (Duration)	0.000	-0.001	0.001	0.002	0.000	0.003	-0.001	-0.010	0.008
Garden visit (Frequency)	0.003	-0.004	0.014	0.031	0.021	0.041	0.031	0.021	0.040
Garden visit (Duration)	0.000	-0.001	0.002	0.000	-0.001	0.001	0.000	-0.001	0.001

Table S6: Outputs from the multivariate regression analysis showing (i) the model coefficients for each social cohesion dimension; and (ii) the significance level of each predictor when the response variable comprised all three dimensions of social cohesion. Positive model coefficients indicate that strength of social cohesion increased with larger values of the predictor. Only the retained predictors from the best-fitting model are shown. Significance: * $p < 0.05$; * * $p < 0.01$; * * * $p < 0.001$.

Predictor variables	**Cohesion (Trust)**	**Cohesion (Interactions)**	**Cohesion (General)**	**Cohesion (Combined)**
Age	-0.004	-0.008	-0.010	***
Gender (female)	-0.111	-0.116	-0.091	*
Ethnicity (Malay)	0.132	0.053	0.035	
Ethnicity (Indian)	0.049	0.224	0.146	*
Ethnicity (Eurasian)	-0.139	0.032	0.076	
Ethnicity (Others)	-0.133	-0.03	0.083	
Occupation (not working but looking for job)	-0.353	-0.282	-0.241	**
Occupation (home duties)	-0.126	-0.094	-0.12	
Occupation (don't work)	0.358	-0.033	0.106	
Occupation (retired)	0.219	0.283	0.188	*
Occupation (student)	-0.136	-0.289	-0.039	*
Income	0.000	0.000	0.000	*
House type (3-5 room flat HDB/ Government Executive flat)	0.378	0.235	0.053	*
House type (Condo/Private flat/Apartment)	0.515	0.311	0.207	**
House type (Terrace/ Semi-detached house/ Bungalow)	0.347	0.051	0.047	
Number of children	0.079	0.103	0.024	***
Number of adults	0.053	0.021	0.017	*
NR_Exp	0.175	0.174	0.125	***
NR_Per	-0.050	-0.373	-0.128	***
NR_Self	0.143	0.155	0.219	***
Green space visit (duration)	0.002	0.005	0.002	
Green space visit (frequency)	-0.005	-0.016	0.013	
Garden visit (frequency)	0.094	0.075	0.045	***

Table S7: The AIC scores for each respective model used in the information theoretic approach that investigated the relationship between frequency of garden use and predictors. The top models for each respective response variable were selected based on the AIC scores and highlighted in bold.

	Model	**AIC1**
	Null model	
1	1	1715.3
	Full model	
2	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + NR_Exp + NR_Per + NR_Self	**1502.0**
	Model with only socio-demographic variables to control confounding effects	
3	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation	1699.6
4	Frequency (Park) + Duration (Park)	1521.3
5	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Frequency (Park)	1563.0
6	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Duration (Park)	1637.8
7	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Frequency (Park) + Duration (Park)	1531.2
8	Vege1500 + Vege250	1718.8
9	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege250	1701.5
10	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege250 + Frequency (Park) + Duration (Park) + NR_Exp + NR_Per + NR_Self	**1500.2**
11	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500	1701.4
12	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Frequency (Park) + Duration (Park) + NR_Exp + NR_Per + NR_Self	**1500.1**
13	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250	1703.4
14	NR_Exp + NR_Per + NR_Self	1616.6
15	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	1613.5
16	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + NR_Exp	1503.1
17	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + NR_Exp + NR_Per	1505.1
18	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + NR_Exp + NR_Self	**1500.5**
19	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + NR_Per	1535.8
20	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + NR_Per + NR_Self	1513.7

21	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + NR_Self	1512.1
22	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Frequency (Park) + NR_Exp + NR_Per + NR_Self	1522.9
23	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Duration (Park) + NR_Exp + NR_Per + NR_Self	1580.7

Table S8: The model-averaged coefficients and confidence intervals of each factor on the frequency of garden visits. The model-averaged coefficients and confidence intervals for categorical factors are presented relative to a comparative base factor level (Ethnicity: Chinese; Occupation: Working; Housetype: public, small). Please refer to Figure 2 in the main manuscript for a graphical representation of these values.

Variable	**Coefficient**	**CI2.5**	**CI97.25**
Intercept	-3.417	-4.765	-2.074
Age	0.005	-0.007	0.016
Gender (Female)	-0.186	-0.445	0.074
Ethnicity (Malay)	-0.280	-0.684	0.125
Ethnicity (Indian)	-0.112	-0.590	0.365
Ethnicity (Eurasian)	0.644	-0.582	1.870
Ethnicity (Others)	-0.225	-0.985	0.534
Occupation (looking for a job)	-0.030	-0.681	0.622
Occupation (home duties)	0.601	-0.118	1.320
Occupation (don't work)	1.134	-0.441	2.710
Occupation (retired)	0.238	-0.453	0.930
Occupation (student)	-0.510	-1.170	0.151
Income	0.000	0.000	0.000
Length of stay in current residence	0.000	-0.013	0.012
HouseType (public, large)	-0.008	-0.696	0.680
HouseType (private, small)	0.010	-0.760	0.779
HouseType (private, large)	0.046	-0.877	0.968
Number of children in family	0.076	-0.059	0.211
Number of adults in family	-0.027	-0.119	0.065
NR-Self	0.332	0.036	0.628
NR-Perspective	-0.060	-0.302	0.141
NR-Experience	0.482	0.223	0.742
Vegetation (250m buffer)	0.086	-1.110	1.360
Vegetation (1.5 km buffer)	-0.187	-1.630	1.090
Green space visit (Frequency)	0.329	0.253	0.405
Green space visit (Duration)	0.048	0.024	0.073

Table S9: The QAIC scores for each respective model used in the information theoretic approach that investigated the relationships between each dimension of social cohesion (i.e. general social cohesion; trust and sense of community; and social interactions), and predictors, using pooled data for frequency of garden and green space use. The top models for each social cohesion dimension were selected based on the QAIC scores and highlighted in bold. QAIC1 represent models with "trust and sense of community" as the response variable; QAIC2 for models with "social interactions" was the response variable; and QAIC3 for models with "general social cohesion" as the response variable.

	Model	**QAIC1**	**QAIC2**	**QAIC3**
	Null model			
1	1	3768.9	4650.3	6413.9
	Full model			
2	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + LengthofStay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	3713.4	4429.9	**6222.5**
	Model with only socio-demographic variables to control confounding effects			
3	Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation	3754.1	4556.0	6331.9
4	Frequency (Park) + Duration (Park)	3757.0	4623.1	6376.6
5	Frequency (Garden) + Duration (Garden)	3733.6	4609.8	6370.0
6	Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden)	3734.6	4599.1	6359.9
7	Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	**3710.6**	**4427.3**	6223.3
8	NR_Exp	3727.2	4590.9	6317.1
9	NR_Per	3770.3	4589.4	6415.3
10	NR_Self	3736.9	4626.0	6325.4
11	NR_Exp + NR_Per + NR_Self	3723.8	4489.3	6282.1
12	Vege1500 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	3711.9	**4428.3**	**6220.5**
13	Vege1500 + Vege250	3772.8	4653.6	6415.0
14	Vege1500 + Vege250 + Frequency (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	**3711.8**	4432.0	**6221.4**
15	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	3725.4	4443.0	6227.9

16	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	**3711.5**	**4428.2**	**6220.9**
17	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation	3730.7	4525.0	6289.0
18	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp	3713.0	4506.4	6247.8
19	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per	3714.8	4434.3	6243.4
20	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	3727.3	4444.8	6229.5
21	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Self	3712.2	4508.4	6234.6
22	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Per	3732.3	4471.1	6289.9
23	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Per + NR_Self	3719.1	4443.4	6232.1
24	Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Self	3717.7	4519.7	6243.3
25	Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	3720.7	4442.0	6232.0
26	Vege1500 + Vege250 + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	**3709.9**	4430.8	**6220.8**
27	Vege1500 + Vege250 + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	**3711.4**	**4429.1**	**6221.7**
28	Vege250 + Frequency (Park) + Duration (Park) + Frequency (Garden) + Duration (Garden) + Age + Ethnicity + Gender + Housetype + Income + Lengthofstay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	**3711.6**	**4429.2**	6224.8

Table S10: The model-averaged coefficients and confidence intervals of each factor on each of the three social cohesion measurements (from the single-cohesion-scale analyses): general social cohesion (SC_General), social interactions (SC_Interaction), and trust and sense of community (SC_Trust), using pooled data for frequency of garden and green space use. The model-averaged coefficients and confidence intervals for categorical factors are presented relative to a comparative base factor level (Ethnicity: Chinese; Occupation: Working; Housetype: public, small).

	SC_General			SC_Interaction			SC_Trust		
Variable	**Coeff.**	**CI2.5**	**CI97.25**	**Coeff.**	**CI2.5**	**CI97.25**	**Coeff.**	**CI2.5**	**CI97.25**
Intercept	2.311	2.150	2.470	2.607	2.440	2.770	2.143	1.982	2.304
Age	-0.004	-0.005	-0.003	-0.004	-0.005	-0.002	-0.001	-0.003	0.000
Gender (Female)	-0.038	-0.069	-0.007	-0.051	-0.082	-0.019	-0.039	-0.069	-0.008
Ethnicity (Malay)	0.011	-0.037	0.058	0.024	-0.024	0.072	0.044	-0.002	0.090
Ethnicity (Indian)	0.056	0.002	0.109	0.096	0.042	0.150	0.022	-0.031	0.076
Ethnicity (Eurasian)	0.022	-0.110	0.155	0.025	-0.112	0.163	-0.041	-0.176	0.093
Ethnicity (Others)	0.028	-0.063	0.118	-0.006	-0.100	0.088	-0.044	-0.136	0.048
Occupation (looking for a job)	-0.112	-0.193	-0.031	-0.141	-0.224	-0.058	-0.135	-0.215	-0.055
Occupation (home duties)	-0.058	-0.148	0.032	-0.036	-0.126	0.054	-0.041	-0.127	0.046
Occupation (don't work)	0.039	-0.173	0.251	-0.032	-0.258	0.193	0.123	-0.073	0.320
Occupation (retired)	0.087	0.006	0.167	0.126	0.046	0.207	0.074	-0.003	0.151
Occupation (student)	-0.017	-0.090	0.056	-0.140	-0.218	-0.062	-0.048	-0.121	0.025
Income	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Length of stay in current residence	-0.001	-0.002	0.001	0.001	-0.001	0.002	0.001	-0.001	0.002
HouseType (public, large)	0.033	-0.048	0.113	0.107	0.023	0.191	0.140	0.057	0.223
HouseType (private, small)	0.092	0.003	0.181	0.142	0.050	0.235	0.190	0.099	0.281
HouseType (private, large)	0.030	-0.077	0.138	0.023	-0.089	0.136	0.126	0.018	0.235
Number of children in family	0.010	-0.005	0.026	0.043	0.028	0.058	0.027	0.012	0.042
Number of adults in family	0.008	-0.002	0.019	0.007	-0.003	0.018	0.017	0.007	0.027
NR-Self	0.091	0.056	0.126	0.060	0.025	0.096	0.049	0.015	0.084
NR-Perspective	-0.052	-0.078	-0.027	-0.156	-0.182	-0.130	-0.018	-0.043	0.007
NR-Experience	0.057	0.027	0.088	0.083	0.051	0.114	0.064	0.034	0.094

Vegetation (250m buffer)	-0.001	-0.150	0.146	-0.025	-0.206	0.099	0.070	-0.057	0.232
Vegetation (1.5 km buffer)	0.184	0.022	0.347	0.066	-0.045	0.285	0.043	-0.098	0.226
Green space visit (Frequency)	0.003	-0.004	0.014	-0.006	-0.016	0.003	-0.001	-0.011	0.007
Green space visit (Duration)	0.001	-0.001	0.002	0.002	0.000	0.003	0.000	-0.001	0.002
Garden visit (Frequency)	0.017	0.007	0.027	0.028	0.017	0.038	0.030	0.020	0.039
Garden visit (Duration)	0.000	-0.001	0.001	0.000	-0.001	0.001	0.000	-0.001	0.001

Table S11: Outputs from the multivariate regression analysis showing (i) the model coefficients for each social cohesion dimension; and (ii) the significance level of each predictor when the response variable comprised all three dimensions of social cohesion, using pooled data for frequency of garden and green space use. Positive model coefficients indicate that strength of social cohesion increased with larger values of the predictor. Only the retained predictors from the best-fitting model are shown. Significance: * $p < 0.05$; * * $p < 0.01$; * * * $p < 0.001$.

Predictor variables	**Cohesion (Trust)**	**Cohesion (Interactions)**	**Cohesion (General)**	**Cohesion (Combined)**
Age	-0.004	-0.008	-0.010	***
Gender (female)	-0.110	-0.116	-0.091	*
Ethnicity (Malay)	0.125	0.048	0.032	
Ethnicity (Indian)	0.050	0.224	0.146	**
Ethnicity (Eurasian)	-0.134	0.038	0.081	
Ethnicity (Others)	-0.141	-0.038	0.077	
Occupation (not working but looking for job)	-0.355	-0.280	-0.242	**
Occupation (home duties)	-0.122	-0.087	-0.114	
Occupation (don't work)	0.372	-0.019	0.115	
Occupation (retired)	0.225	0.292	0.193	*
Occupation (student)	-0.135	-0.287	-0.040	
Income	0.000	0.000	0.000	*
House type (3-5 room flat HDB/ Government Executive flat)	0.372	0.233	0.052	*
House type (Condo/Private flat/Apartment)	0.509	0.307	0.206	**
House type (Terrace/ Semi-detached house/ Bungalow)	0.341	0.052	0.048	
Number of children	0.081	0.106	0.026	***
Number of adults	0.053	0.021	0.017	*
NR_Exp	0.186	0.184	0.131	***
NR_Per	-0.053	-0.375	-0.129	***
NR_Self	0.146	0.159	0.222	***
Green space visit (duration)	0.002	0.005	0.003	
Green space visit (frequency)	-0.007	-0.017	0.014	
Garden visit (frequency)	0.092	0.066	0.039	***

Table S12: The AIC scores for each respective model used in the information theoretic approach that investigated the relationship between frequency of garden use and predictors, using pooled data for frequency of garden and green space use. The top models for each respective response variable were selected based on the AIC scores and highlighted in bold.

	Model	**AIC**
	Null model	
1	1	1715.3
	Full model	
2	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + NR_Exp + NR_Per + NR_Self	**1524.8**
	Model with only socio-demographic variables to control confounding effects	
3	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation	1699.6
4	Frequency (Park) + Duration (Park)	1550.5
5	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Frequency (Park)	1595.6
6	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Duration (Park)	1637.8
7	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Frequency (Park) + Duration (Park)	1558.5
8	Vege1500 + Vege250	1718.8
9	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege250	1701.5
10	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege250 + Frequency (Park) + Duration (Park) + NR_Exp + NR_Per + NR_Self	**1523.1**
11	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500	1701.4
12	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Frequency (Park) + Duration (Park) + NR_Exp + NR_Per + NR_Self	**1522.8**
13	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250	1703.4
14	NR_Exp + NR_Per + NR_Self	1616.6
15	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + NR_Exp + NR_Per + NR_Self	1613.5
16	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + NR_Exp	1526.5
17	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + NR_Exp + NR_Per	1528.5
18	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + NR_Exp + NR_Self	**1523.2**

19	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + NR_Per	1562.6
20	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + NR_Per + NR_Self	1537.6
21	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Frequency (Park) + Duration (Park) + NR_Self	1536.0
22	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Frequency (Park) + NR_Exp + NR_Per + NR_Self	1548.8
23	Age + Ethnicity + Gender + Housetype + IncomeN + LengthofStay + NumAdults + NumChildren + Occupation + Vege1500 + Vege250 + Duration (Park) + NR_Exp + NR_Per + NR_Self	1580.7

Table S13: The model-averaged coefficients and confidence intervals of each factor on the frequency of garden visits, using pooled data for frequency of garden and green space use. The model-averaged coefficients and confidence intervals for categorical factors are presented relative to a comparative base factor level (Ethnicity: Chinese; Occupation: Working; Housetype: public, small).

Variable	**Coefficient**	**CI2.5**	**CI97.25**
Intercept	-3.396	-4.730	-2.062
Age	0.005	-0.007	0.016
Gender (Female)	-0.191	-0.448	0.066
Ethnicity (Malay)	-0.290	-0.691	0.112
Ethnicity (Indian)	-0.118	-0.591	0.355
Ethnicity (Eurasian)	0.661	-0.560	1.881
Ethnicity (Others)	-0.248	-0.998	0.503
Occupation (looking for a job)	-0.032	-0.677	0.613
Occupation (home duties)	0.606	-0.105	1.317
Occupation (don't work)	1.119	-0.449	2.686
Occupation (retired)	0.247	-0.435	0.929
Occupation (student)	-0.522	-1.178	0.133
Income	0.000	0.000	0.000
Length of stay in current residence	-0.001	-0.013	0.011
HouseType (public, large)	0.005	-0.676	0.686
HouseType (private, small)	0.036	-0.726	0.798
HouseType (private, large)	0.047	-0.867	0.960
Number of children in family	0.079	-0.055	0.213
Number of adults in family	-0.024	-0.115	0.067
NR-Self	0.352	0.059	0.644
NR-Perspective	-0.055	-0.295	0.145
NR-Experience	0.498	0.241	0.755
Vegetation (250m buffer)	0.065	-1.135	1.327
Vegetation (1.5 km buffer)	-0.289	-1.746	0.943
Green space visit (Frequency)	0.285	0.208	0.362
Green space visit (Duration)	0.052	0.027	0.078