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Beyond proximity: The importance of green space useability to self-reported health

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Abstract

Access to parks and green spaces within residential neighbourhoods has been shown to be an important pathway to generating better physical and mental health for individuals and communities. Early research in this area often failed to identify specific attributes that contributed to reported health outcomes, with more recent research focused on exploring relationships between health outcomes and aspects of access and design. A mixed methods research project conducted in Perth, Western Australia examined the role that neighbourhood green space played in influencing residents' self-reported health status, and this paper identifies significant relationships found between perceptions of green space quality and self-reported health. It focuses on the factors that were found to be most positively associated with better health outcomes: proximity, retention, useability and visitation of neighbourhood green space.

Introduction

Access to parks and green spaces within residential neighbourhoods has been shown to be an important pathway to generating better physical and mental health for individuals and communities (Kessel et al., 2009; Maas, Verheij, Groenewegen, De Vries, & Spreeuwenberg, 2006; O'Campo, Salmon, & Burke, 2009). Urban parks and green spaces provide places for sport and active recreation, places to relax and enjoy solitude, places to meet other people and socialise, and places that evoke feelings of connection to the natural world (Maller et al., 2008).

Some early research in this area has been criticised for not identifying specific environmental factors or other open space attributes that contributed to reported health outcomes (Kaczynski & Henderson, 2007). More recent research has focused on aspects such as green space access and design, with results suggesting that perception of park quality is an important factor in encouraging use for physical activity (Crawford et al., 2008) and lowering psychosocial distress (Francis, Wood, Knuiman, & Giles-Corti, 2012). Other findings include proximity to large neighbourhood parks being positively associated with increased physical activity (Giles-Corti et al., 2005), neighbourhood greenness being positively associated with increased walking, social coherence and local social interaction (Sugiyama, Leslie, Giles-Corti, & Owen, 2008) and with reduced body weight (Pereira et al., 2013), improvements in park infrastructure resulting in increased use (Veitch, Ball, Crawford, Abbott, & Salmon, 2012), and how open space design (in this case an open lawn area) may influence type of use and length of stay (Goliˇcnika & Ward Thompson, 2010).

A mixed methods research project conducted in Perth, Western Australia examined the role that neighbourhood green space played in influencing residents' self-reported health status, and this paper identifies significant relationships found between perceptions of green space and self-reported health. It focuses on the factors that were found to be most positively associated with better health outcomes: proximity, retention, useability and visitation of neighbourhood green space.

Methodology

Four neighbourhoods in the Perth metropolitan area were selected as representative of the main types of urban residential developments found in the city. Two inner suburban neighbourhoods were chosen, one being Subiaco, an established neighbourhood with diverse architectural heritage, and the other Subiaco Centro a new higher density development, incorporating New Urban design principles (Calthorpe, Fishman, & Lerup, 2005). Two outer suburban neighbourhoods were included: Wanneroo, an established neighbourhood of relatively homogenous age and design, and Ashby, a new greenfield development. Table 1 provides an overview of locational and historical contexts of selected neighbourhoods.

Parks and green spaces within each neighbourhood were distinctly different. Those in the older neighbourhoods of Subiaco and Wanneroo were shady with established large trees. Subiaco parks contained well maintained gardens that reflected the early European settlement of the area. Wanneroo parks included a greater variety of Australian native and endemic species. Parks in the newer neighbourhoods of Subiaco Centro and Ashby mostly consisted of fewer, smaller trees, flat grass lawns, paths and playgrounds. Overall appearance of the central park in Subiaco Centro was manicured with hard landscaped edges and plantings of mostly exotic species. Most Ashby parks were ringed by road and consisted of a flat mown lawn with new tree plantings and a colourful playground.

Apart from physical aspects of the neighbourhood and access to different types of nearby green space, local demographic composition was also considered. While the primary focus of this paper is to report on overall findings, reference to significant differences found between neighbourhoods is discussed where relevant.

Approval for this project was granted by the Edith Cowan University Human Research Ethics Committee.

[Insert Table 1 here]

Data collection

A mixed methods research design was adopted in this study. Exploration of research questions required objective measurement of relationships between different aspects of health and nature, and interpretation of the subjective meanings people attach to those relationships. The major advantage of using a mixed method approach is the combined strengths of quantitative and qualitative methodologies in assisting to develop and inform the data collected, and provide insight into different levels of analysis (Creswell, 2014).

Data was collected through survey and interview using an explanatory sequential strategy as described by Creswell (2014). This model is characterised by the collection of quantitative data, followed by qualitative data, with integration of the two methods during initial interpretation.

The survey questionnaire contained mostly closed-ended questions and scalar measures and included socio-demographic data, proximity to green space, how often people visited and perceptions of nearby green space, and self-reported health. Open-ended questions asked for descriptions of nearby favourite places and for additional comment.

Questionnaire format was based on accepted typologies or previously validated scales. Proximity questions were based on a typology of urban green space that enabled assessment of perceived proximity and diversity (Tzoulas & James, 2004, 2005). Perceptions of green space were measured using Likert-type scales included as part of the Perceptions of Residential Quality (PREQ) scale (Bonaiuto, Aiello, Perugini, Bonnes, & Ercolani, 1999; Bonaiuto, Fornara, & Bonnes, 2003). The SF-36v2™ health survey was used to measure self-reported physical and mental health (Ware et al., 2007; Ware, Kosinski, & Dewey, 2000).

Interviews began by asking about each individual's personal situation (such as age, qualifications and living arrangements). Initial questions explored how long participants had lived in their current home, why they chose to live in that neighbourhood and perceptions of their neighbourhood. Subsequent interview questions were framed to explore the key themes of attitude to nature and the

environment, perceptions of green space, neighbourhood attachment, and health. At one level, interview questions focused on expanding understanding of the quantitative survey responses and relationships (or lack of) noted in preliminary data analysis. At a second level, questions were designed to explore meanings given to nature and understandings of relationships between green space and health as these questions were not specifically addressed in the survey questionnaire.

A naturalistic process of enquiry was used in all interviews. This approach is discovery-orientated and lacks pre-determined constraints on outcomes (Patton, 1990). The interview schedule was used as a guide and essentially provided a checklist to ensure all relevant topics were discussed at some point during the interview. Interview time was between 35 and 90 minutes, with most interviews lasting about one hour.

Sample grid and survey distribution

Survey and interview data were collected over a six-month period from June to December 2006. A grid for distribution of the questionnaire (and interview invitation) was drawn for the four neighbourhoods with each containing at least 500 homes. Where possible, sample grid boundaries were aligned with Australian Bureau of Statistics (ABS) census collection districts. In new neighbourhoods, cadastral maps obtained from each local government authority were used to identify the number of planned house lots. Based on available information at the time, 500 homes represented almost all of the completed residences in Ashby and Subiaco Centro.

One resident in each of 500 homes in the four selected neighbourhoods was invited to participate in the study. A response rate of 22.5 per cent generated sufficient responses to construct a useable sample (n=440) for statistical analysis, though the number of respondents within each neighbourhood varied considerably (144 from Subiaco, 114 from Wanneroo, 100 from Ashby and 82 from Subiaco Centro). Table 2 provides a breakdown of socio-demographic characteristics for respondents overall and within each neighbourhood. Study samples were relatively consistent with the population composition of each neighbourhood at that time.

The survey pack also included an invitation to participate in a face-to-face interview that would further explore possible relationships between green space and health. More than 140 people (approximately 32% of survey respondents) volunteered for face-to-face interview. From these, 25 people were selected to form a stratified sample based on gender, age and time lived in neighbourhood. Interview participants were invited to choose their own pseudonym and their choices are used in this paper.

[Insert Table 2 here]

Data analysis

Quantitative analysis was undertaken using SPSSv14 software and specialised scoring software for the SF-36v2™ health survey (Pallant, 2001, 2007; Ware et al., 2007; Ware, Kosinski, & Dewey, 2000). Data analysis was conducted in several steps that included: preliminary descriptive analysis to identify patterns of response (frequency and cross-tabulation); and exploratory factor analysis using principal component analysis (PCA) to identify underlying themes and common factors to reduce data to a smaller set of compound (or transformed) variables. Transformed variables relating to proximity and perceptions of green space, attitude to nature and neighbourhood attachment were identified through PCA, with transformed variables scores calculated using item weightings identified as part of the PCA process (Field, 2000). Correlation analysis for non-parametric data (Spearman rho two-tailed test) was used to explore linear relationships between variables; and analysis of variance (Kruskal-Wallis and Mann-Whitney U tests) to identify significant differences between neighbourhoods.

Use of the SF-36v2™ health survey generates scores in two overarching domains: physical health and mental health. Within each domain, scores for four related factors contribute to the overall score. Within the physical health domain, these four factors are: physical function, role physical, bodily pain and general health. Within the mental health domain, these four factors are: social function, role emotional, vitality and mental health (Ware et al., 2007; Ware et al., 2000).

In the final stage of analysis, bivariate logistic regression was used to determine whether selected compound variables might predict health outcomes. Forced entry

logistic regression models were constructed with a single block of predictor variables. The effect of each variable was independently assessed, with possible confounding effects of socio-demographic variables (such as age or income) taken into account and included in regression models. Significant effect of any independent predictor variable was identified through production of an odds ratio (+/-1.0) (Harlow, 2005).

To predict effect on health outcomes using bivariate logistic regression, scores within physical and mental health domains were split into dichotomous categories. In this case, scores equal to the identified median or below (coded as 0) indicated poorer health and above median scores (coded as 1) indicated better health.

Comprehensive analysis of the final data set used a concurrent triangulation model, with simultaneous analysis of quantitative and qualitative data used to confirm, cross-validate and corroborate findings(Creswell, 2014). Within this model, data analysis was ongoing with interpretation noting either convergence of findings, or providing explanations for anomalies or inconsistencies (see Carter, 2009). This is a traditional approach to mixed methods data analysis and because of the possible convergence of findings, can produce well-validated results (Creswell, 2014; Creswell & Plano Clark, 2007). Accordingly, for the purpose of this paper, data are presented sequentially, with confirmatory qualitative data following the quantitative analyses.

Results: Quantitative data

Factor analysis (PCA) of questions relating to proximity to green space resulted in two compound variables (factors) being formed: (1) *parks and social spaces* (parks and gardens and play/social spaces); and (2) *larger green spaces and trees* (bushland, sport and recreation facilities, and green corridors and private gardens with trees).

Factor analysis (PCA) of questions relating to perceptions of green space quality resulted in three compound variables being formed: (1) *retention of green spaces and bushland* (based on green areas [not] disappearing, having access to enough bushland, and not having to travel out of neighbourhood to go to bushland area); (2) *useability* (based on green spaces being in good condition, well-equipped for visiting, and

including places to relax and meet others); and (3) *enough space* (places for free play, open to the public, and areas that are not too small).

Second stage logistic regression analysis included all of these variables as well as socio-demographic variables (such as age, education, income and family type) and each of the underlying factors associated with physical and mental health.

Proximity

Proximity to parks and social green spaces was most commonly reported (>80% of respondents). Proximity to large spaces with trees such as bushland, sports fields, green streetscapes and private yards with large trees was reported by fewer respondents, particularly those in new neighbourhoods (see Table 3). Within the factor analysis process, a negative relationship was evident between these two factors, indicating that where respondents reported the highest level of proximity to parks and social green spaces, they were less likely to report proximity to areas with larger green spaces with trees.

[Insert Table 3 here]

Perceptions of green space quality

Within the factor analysis, a positive relationship was evident between two factors (*retention of green spaces and bushland* and *enough green space*) indicating that where respondents perceived that green spaces were being retained, they were also likely to report that their neighbourhood had enough space. Comparison of mean scores by neighbourhood location indicated respondents in new neighbourhoods (Subiaco Centro and Ashby) provided less positive responses to survey questions relating to retention of green spaces or there being enough space (see Table 4).

In relation to the third factor, the respondents in the inner suburban neighbourhoods of Subiaco and Subiaco Centro recorded significantly higher mean scores for green space *useability* and as such, were more likely to agree that green spaces were in good condition, well-equipped for visiting and there were places they could go to relax and

meet others. The least positive responses were reported by people living in Ashby (see Table 4).

[Insert Table 4 here]

Visitation

More than half of all respondents (57%) visited green space at least once per week. Respondents from Ashby reported substantially less regular visitation (only 42%) (see Table 5) even though a majority reported living within walking distance of parks, play spaces and bushland (see Table 3).

[Insert Table 5 here]

Combined data from all neighbourhoods were analysed using logistic regression modelling to identify patterns of association between green space factors and physical and mental health factors. Four green space factors (*proximity to play and social spaces, retention of green spaces and bushland, useability* and *visitation*) were found to generate a significant pattern of positive effect (where $p \leq 0.1$) on different aspects of self-reported health (see Table 6). The last row of Table 6 lists the socio-demographic and other variables that were included in each regression model. These variables were identified through univariate analysis as being significantly associated (where $p \leq 0.250$) with the various physical and mental health factors.

[Insert Table 6 here]

Results: Qualitative data

While all respondents discussed their use of green space for physical activity such as walking, running and riding, walking dogs or playing with children, they spoke more about the way being in green spaces made them feel. Most stated that going to the park made them feel happier or more relaxed and improved their mood. Beyond this, the interview data provides some clarity about the qualities of green spaces that makes them useable and the highly significant association of this factor with general health.

I think it's really important for your emotional health or your psychological health to be surrounded by green things and blue sky … It's part of the reason why I walk every day because I find it lifts my mood a bit, especially if you're feeling down. I notice, when I'm down there and I'm walking along and I see the dogs playing and looking at the wildlife, I feel very happy. It gives me a little lift. I just really, really like going out every day and walking. I really miss it if I can't do it. (Chloe, 55, Wanneroo)

If you're in a street, you're just closed in and you haven't got much to look at… whereas just going to the park, there's so much round about, so much to look at, and if you're lucky enough you've got the birds singing and you see other people and they all seem to be happy. You don't really meet people who are unhappy when they're walking out in the park. (Sue, 70, Subiaco Centro)

I think it just makes you feel happier … I do think it's important for all people. I don't think it's just me … I really think that somewhere in people's hearts, it is important whether they consciously think it or not and I think it's just part of general wellbeing. People are better off. Good for the soul. (Sarah, 26, Ashby)

Parks and green spaces provided opportunities to relax, to feel less stressed and were places away from busy urban environments.

I think it's relaxing … it does generate a few different emotions – relaxing is one of the major ones of it, a sense of well-being, just the freshness of it and you actually think that you're doing something good for yourself. (Andrew, 37, Subiaco Centro)

Well, just being in Kings Park … there's different types of relaxation there. I find it relaxing just going along through the paths, cycle paths or walking paths when it's not too crowded … you might hear the noise a bit, but it's somewhere to enjoy the peace and … you're reminded of how separate you are from all the sort of city goings on, the noise and the busyness (Mark, 58, Subiaco).

If you can listen outside and hear birds and wind as opposed to cars and traffic and all that sort of stuff, it does make you feel less stressed. Just to know that you've got somewhere that you can go if you need to get out in nature … some nice [place] to walk around in if you wanted to. It's hard to explain, it just makes you feel … more relaxed and sort of just healthier thinking that you're breathing air that has not got so many cars and people in it, and more trees in it, you just feel like you're healthier being surrounded by that. (Tash, 37, Wanneroo)

In essence, the green places that interviewees described as being most beneficial were "somewhere that you can go if you need to get out in nature" with wildlife, birds, trees and a sense of "freshness" where they could escape the noise and busyness of the city.

For others like Amber who had recently moved from inner suburban Subiaco to outer suburban Ashby, she missed walking around her old neighbourhood and felt the nearby park did not provide useable qualities. She spoke of often driving out of Ashby to access more useable green spaces that provided opportunity for her children to play with others, and she was disappointed that she could not visit these places as often as she would like.

> *It's not very exciting, it's not relaxing, it's boring. … I actually think it translates to being less active because I don't go for a walk here because it's boring. But when I lived in Subiaco I used to go every day because I had somewhere nice to walk and nice to take the children and look at the trees and the birds and things, whereas here I take them up the park but that's across the street and then we'd walk around the park and come back … I don't go for an hour walk whereas I used to do that all the time … I find it a nice way to kind of get your thoughts together* ... (Amber, 33, Ashby)

Amber's story also demonstrates that simply living near a park may not be enough to generate better health outcomes. While she had access to a nearby park, she described it as small and uninteresting and found that it was most often empty of other people. For Amber, a useable green space needed to provide opportunity to interact with others, with trees and birds to look at, where she could enjoy walking for a reasonable length of time.

Discussion: Health and green spaces

Several factors identified in this study demonstrate association with better health outcomes. Retention of green spaces and bushland was positively associated with better self-reported physical function. This may be linked to aspects of size and diversity of landscape, particularly as retained bushland areas tend to be larger tracts of land than the average neighbourhood park. This connection to better physical health is supported by prior research findings that larger areas of green space were more likely to encourage users to be more physically active (Giles-Corti et al., 2005). The finding that proximity to play and social spaces was positively associated with better mental health scores is also supported by previous research. It has been suggested that social interaction in parks and green spaces may act as a mediator to reduce feelings of loneliness and lack of social support (Maas, van Dillen, Verheij, & Groenewegen, 2009).

It has also been suggested that accessing neighbourhood green space can exert stronger positive effect on self-reported mental health, rather than physical health (Francis et al., 2012; Maas et al., 2009; Sugiyama et al., 2008). As the most positive effects were demonstrated in relation to general health and vitality (or subjective well-being), this study provides further support for this argument through the evocative phraseology used by interviewees: '*lifts my mood*', '*good for the soul*', '*makes me happier*' etc.

Of particular interest is the finding that the most significant positive effect was reported between green space useability and general health. Respondents who perceived nearby green space to be useable were twice as likely (OR 2.08, p=0.013) to report better general health than those who did not (see Table 6). As previously described, green space useability was represented, not by type or level of use or visitation, but by perceptions of green spaces being in good condition and well-equipped for visiting with visible access points and pathways, and providing places to relax and meet others.

At one level, it may be reasonable to hypothesise that this result may simply be a correlative effect of socio-economic status. Previous research has shown that wealthier people are more likely to report better general health (Marmot, 2007; Najman, 2001) and better quality green places with a higher standard of park amenity and facilities (such as seating, trees and shade, walking and cycle paths and lighting) are more likely to be found in affluent neighbourhoods (Crawford et al., 2008). Further examination of the results of this study suggests that the relationship between perceptions of green space useability and better general health may not be interpretable in such a straightforward way. The logistic regression models constructed in this study took socio-demographic factors into account (see Table 6). Initial univariate analysis suggested that age was significantly associated with all health factors, and higher socio-economic status (assessed by weekly household income and educational qualifications) with better physical function, mental health and vitality. On the other hand, univariate analysis suggested that self-reported general health was not found to be significantly associated with income or education, while it was significantly associated with gender and cultural background. Gender was also significantly associated with mental health. The question therefore shifts to one of how these determinants might influence

perceptions of green space quality and useability, as well as self-reported general health, vitality and mental health.

The interview data goes some way to answering this question. Perceptions of green space quality emerged as not only being associated with useability but also with aesthetic preference (green and blue colours, fresh, diverse, open and expansive, interesting and not boring), and as an alternative to a stressful life (‘*escape the noise and busyness’*, ‘*get out’*, ‘*relaxation’*, uncrowded).

Gender and cultural background did appear to influence expressions of useability, aesthetic preference and release from stress. While the interview sample was relatively small (*n*=25), male interviewees born in Australia tended to seek out more isolated, bushland environments where they could “*get away*”, while women spoke of preferring to spend time in open parkland environments closer to home where they “*felt safe*” and could socialise with others. Several interviewees with European heritage (both male and female) spoke of preferring to spend time in more cultivated, landscaped environments than densely vegetated, naturalistic environments, perhaps reflecting preference for a more European-influenced aesthetic than that of local Australian landscapes. Based on these preliminary findings, the influence of gender, cultural background and perceptions of green space quality on self-reported health outcomes may deserve further exploration.

Conclusion

Even though this study was restricted to a relatively homogenous sample population living in only four neighbourhoods, specific aspects of green space quality and access were found to be associated with better self-reported health. Proximity to nearby play and social spaces was associated with better mental health, perhaps through increased opportunity for social interaction. Retention of green space and bushland was associated with better physical function, possibility because of size and diversity of landscape and increased opportunity to be physically active for longer in a larger space. Green space useability was associated with better general health and vitality, possibly because positive perceptions of green space quality encouraged and enabled regular

visitation, which in itself, was associated with greater vitality. All of these possibilities deserve further research.

This study also found that while proximity to green space can be important, it is simply not enough, and understanding what constitutes useable green space may be critical in achieving better health outcomes. Incorporating the various desirable qualities of green spaces (such as being accessible, aesthetically pleasing and in good condition, while providing opportunity for activity, relaxation and interaction, access to nature and engendering feelings of openness and escape from busy urban environments) can be challenging. Professionals working in health promotion, green space planning and design, urban conservation, local area planning and residential development will need to collaborate to ensure greater useability of urban green spaces.

References

Calthorpe, Peter , Fishman, Robert , & Lerup, Lars (2005). *New urbanism*: University of Michigan.

Carter, May. (2009). *Health and the nature of urban green spaces*. PhD thesis. Edith Cowan University. Perth, WA.

Crawford, David, Timperio, Anna, Giles-Corti, Billie, Ball, Kylie, Hume, Clare, Roberts, Rebecca, . . . Salmon, Jo (2008). Do features of public open spaces vary according to neighbourhood socio-economic status? *Health & Place, 14*(4), 889-893. doi: doi:10.1016/j.healthplace.2007.11.002

Creswell, John W. (2014). *Research design: qualitative, quantitative and mixed methods approaches*. Thousand Oaks, CA: Sage Publications.

Creswell, John W., & Plano Clark, Vicki L. (2007). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage.

Field, Andy. (2000). *Discovering statistics using SPSS for Windows*. London: Sage.

Francis, Jacinta, Wood, Lisa J. , Knuiman, Matthew, & Giles-Corti, Billie (2012). Quality or quantity? Exploring the relationship between Public Open Space attributes and mental health in Perth, Western Australia. *Social Science & Medicine, 74* 1570-1577. doi: 10.1016/j.socscimed.2012.01.032

Giles-Corti, Billie, Broomhall, Melissa H., Knuiman, Matthew, Collins, Catherine, Douglas, Kate, Ng, Kevin, . . . Donovan, Robert J. (2005). Increasing walking: How important is distance to, attractiveness, and size of public open space? *American Journal of Preventive Medicine, 28*(2S2), 169-176.

Goliˇcnika, Barbara , & Ward Thompson, Catharine (2010). Emerging relationships between design and use of urban park spaces. *Landscape and Urban Planning, 94*, 38-53. doi: 10.1016/j.landurbplan.2009.07.016

Harlow, Lisa L. (2005). *The essence of multivariate thinking: Basic themes and methods*. Mahwah, NJ: Lawrence Erlbaum Associates.

Kaczynski, Andrew T., & Henderson, Karla A. (2007). Environmental correlates of physical activity: A review of evidence about parks and recreation. *Leisure Sciences, 29*(4), 315-354.

Kessel, A., Green, J., Pinder, R., Wilkinson, P., Grundy, C., & Lachowycz, K. (2009). Multidisciplinary research in public health: A case study of research on access to green space. *Public Health, 123* 32-38. doi: 10.1016/j.puhe.2008.08.005

Maas, Jolanda, van Dillen, Sonja M.E., Verheij, Robert A., & Groenewegen, Peter P. . (2009). Social contacts as a possible mechanism behind the relation between green space and health. *Health & Place, 15*(2), 586-595.

Maas, Jolanda, Verheij, Robert A., Groenewegen, Peter P., De Vries, Sjerp, & Spreeuwenberg, Peter. (2006). Green space, urbanity, and health: How strong is the relation? *Journal of Epidemiology and Community Health, 60*, 587-592. doi: doi:10.1136/jech.2005.043125

Maller, Cecily, Townsend, Mardie, St Leger, Lawrence, Henderson-Wilson, Claire, Pryor, Anita, Prosser, Lauren, & Moore, Megan. (2008). *Healthy parks, healthy people: The health benefits of contact with nature in a park context. A review of current literature* (2nd ed.). Melbourne: Deakin University and Parks Victoria.

Marmot, Michael. (2007). Achieving health equity: From root causes to fair outcomes. *The Lancet, 370*(9593), 1153-1164.

Najman, Jake. (2001). A general model of the social origins of health and well-being. In R. Eckersley, J. Dixon & B. Douglas (Eds.), *The social origins of health and well-being* (pp. 73-82). Cambridge: Cambridge University Press.

O'Campo, Patricia, Salmon, Christina, & Burke, Jessica. (2009). Neighbourhoods and mental well-being: What are the pathways? *Health & Place, 15*(1), 56-68.

Pallant, Julie. (2001). *SPSS Survival Manual: A step by step guide to data analysis using SPSS for Windows (Versions 10 and 11)*. Berkshire: Open University Press.

Pallant, Julie. (2007). *SPSS Survival Manual: a step by step guide to data analysis using SPSS for Windows (Version 15)* (3rd ed.). Crows Nest, NSW: Allen & Unwin.

Pereira, Gavin, Christian, Hayley, Foster, Sarah, Boruff, Bryan J., Bull, Fiona, Knuiman, Matthew, & Giles-Corti, Billie (2013). The association between neighborhood greenness and weight status: an observational study in Perth Western Australia. *Environmental Health, 12*, 49. doi: http://www.ehjournal.net/content/12/1/49

Sugiyama, Takemi, Leslie, E., Giles-Corti, Billie, & Owen, N. (2008). Associations of neighbourhood greenness with physical and mental health: Do walking, social coherence and local social interaction explain the relationships? *Journal of Epidemiology and Community Health, 62*, e9. doi: DOI: 10.1136/jech.2007.064287

Veitch, Jenny, Ball, Kylie, Crawford, David, Abbott, Gavin R., & Salmon, Jo (2012). Park Improvements and Park Activity: A Natural Experiment. *American Journal of Preventive Medicine, 42*(6), 616-619. doi: doi: 10.1016/j.amepre.2012.02.015.

Ware, John E. Jr., Kosinski, Mark, Bjorner, Jakob B., Turner-Bowker, Diane M., Gandek, Barbara, & Maruish, Mark E. (2007). *User's manual for the SF-36v2™ Health Survey* (2nd ed.). Lincoln, RI: QualityMetric Incorporated.

Ware, John E. Jr., Kosinski, Mark, & Dewey, James E. (2000). *How to score version 2 of the SF-36 health survey*. Lincoln, RI: QualityMetric Incorporated.

Table 1: Selected neighbourhoods showing locational and historical contexts.

	Inner suburban neighbourhoods	Outer suburban neighbourhoods
Established neighbourhood	**Subiaco**	**Wanneroo**
New neighbourhood	**Subiaco Centro**	**Ashby**
Local Government Authority	City of Subiaco	City of Wanneroo
Location	4km west of Perth Central Business District	22km north of Perth Central Business District
Pattern of development	First settled in 1851 as a Benedictine monastery. Established with light industry and worker accommodation during 19-20th century. Extensive urban infill and regeneration projects since the 1970s have increased the density and diversity of residential property. Redevelopment began in Subiaco Centro in 1997 and it was the first master-planned mixed land-use, medium/high-density residential estate in Perth to incorporate public transport, commercial, residential and recreation areas.	First settled circa 1842. Established as a semi-rural district with market gardens and light industrial areas. Many market garden properties were subdivided the 1970s for residential development. Increased land clearing and development of low density residential estates such as Ashby (approx. 2km north of the Wanneroo town site) approved in 1997.
Access to services, facilities and transport	Neighbourhoods linked by extensive high-street shopping and commercial district with good access to public transport (particularly rail), community facilities and medical services.	Neighbourhoods separated by retail, commercial and agricultural district along main arterial road, serviced by bus. At the time study was undertaken, no community, commercial or retail facilities (except for a petrol station) were located within a 1km radius of the Ashby neighbourhood, and there was no public transport within the neighbourhood.
Nearby green space and community facilities	The City of Subiaco is adjacent to Kings Park (400ha parkland) with bushland, botanical gardens, walk and cycle ways, recreation facilities and picnic areas set in open lawns. Several large parks with community and sporting facilities are found in Subiaco. Subiaco Centro has central linear parklands with ornamental lake and recreational facilities.	The southern region of the City of Wanneroo is adjacent to the eastern section of Yellagonga Regional Park, an extensive lake system with walk trails and cycle ways, playground areas, a recreation centre and junior playing fields. Apart from small local parks with play areas, there are no sporting or community facilities in Ashby. Conti Road Bushland (20ha site) is adjacent to the western boundary of Ashby, and has no recreational facilities, only informal sandy pathways and few access points.

Table 2: Selected socio-demographic characteristics of the study populations – overall and within each neighbourhood (with χ2 test for analysis of variance between neighbourhoods)

		All n=440	Subiaco n=144	Subiaco Centro n=82	Wanneroo n=114	Ashby n=100	χ^2
Gender [a]	Female	64	65	57	62	73	*0.154*
	Male	36	35	43	38	27	
Age [b]		45-54	45-54	45-54	55-64	35-44	*0.000*
Cultural background [a]	Australian	55	60	62	49	46	*0.066*
	British	25	20	15	34	31	
	Other	20	20	23	17	23	
Household weekly income [b]		$1000-1499	$1000-1499	$1500+	$500-999	$1000-1499	*0.000*
Educational qualifications [a]	School or trade	53	31	37	78	71	*0.000*
	University	47	69	63	22	29	
Living arrangement [a]	Single	23	27	33	22	9	*0.000*
	Couple	42	40	48	41	42	
	Family	34	33	18	33	48	
Own/rent home [b]	Own	81	76	73	84	93	*0.001*
	Rent	19	24	27	16	7	
Time lived in neighbourhood [b]		1-5 years	6-10 years	1-5 years	11-20 years	<1year	*0.000*

[a] *% in each category*
[b] *Median category*

Table 3: Proportion of respondents who reported proximity (within 500 metres of home) to different types of neighbourhood green space

Type of green space	All	Subiaco	Subiaco Centro	Wanneroo	Ashby	*p*=‡
PARKS AND SOCIAL GREEN SPACES						
Parks and gardens *including mown grass parkland with trees, formal public and/or botanical gardens*	**90.5%**	97.9	93.9	81.6	87.0	*0.000*
Play and social green spaces *including play grounds and meeting/ hanging out areas*	**85.7%**	84.7	86.6	83.3	89.0	*0.666*
LARGER GREEN SPACES AND/OR SPACES WITH TREES						
Sports and recreation facilities *including sports ovals, playing fields, golf courses and other sports areas, cycle and walk paths*	**68.4%**	77.1	76.8	88.6	26.0	*0.000*
Bushland *including bushland, wetlands and bush areas around rivers or lakes*	**60.2%**	65.3	7.3	87.7	65.0	*0.000*
Green corridors *including footpaths and verges, road and rail corridors, rights of way*	**59.3%**	65.3	69.5	57.9	44.0	*0.001*
Private yards and/or gardens with large trees	**59.3%**	80.6	35.4	72.8	33.0	*0.000*

‡ $\chi 2$ test for analysis of variance between neighbourhoods

Table 4: Mean ranking by neighbourhood for factors relating to perceptions of green space quality

		Mean ranking†			
	(*p* value) ‡	**Subiaco**	**Wanneroo**	**Ashby**	**Subiaco Centro**
Retention of green spaces and bushland	*0.000*	**1**	**2**	**3**	**4**
Enough green space¤	*0.000*	**1**	**2**	**4**	**3**
Green space useability	*0.000*	**2**	**3**	**4**	**1**

†Kruskal-Wallis or Mann Whitney-U test for mean rank with χ^2 test for asymmetrical significance of variance
‡Tukey post hoc testing of ANOVA with mean difference significant at $p \leq 0.05$ level

Table 5: How often people usually visited nearby green space (overall and by neighbourhood)

Visit nearby green space ($\chi 2$=0.012) ‡	Overall n=440	%	Subiaco % (n=144)	Wanneroo % (n=114)	Ashby % (n=100)	Subiaco Centro % (n=82)
More than once a week	*250*	**56.9**	63.2	61.1	42.0	58.5
More than once a fortnight	*76*	**17.3**	17.4	15.9	21.0	14.6
More than once a month	*46*	**10.5**	7.6	11.5	18.0	4.9
Less than once a month	*67*	**15.3**	11.8	11.5	19.0	22.0

‡ Chi-square result from cross-tabulation analysis by neighbourhood location

Table 6: Significant patterns of effect (where p≤0.1) for green space-related variables with odds ratio (OR) associated with better self-reported health outcomes (with socio-demographic and other variables included in each model listed below)

Green space-related variables	Physical function	General health	Mental health	Vitality (well-being)
PROXIMITY				
Play and social spaces				
Low			1.00	
Medium			**1.62 (*p*=0.088)†**	
High			**1.70 (*p*=0.079)†**	
PERCEPTIONS OF GREEN SPACE QUALITY				
Retention of green spaces and bushland				
Low	1.00			
Medium	**1.67**			
High	**1.82 (*p*=0.097)†**			
Green space useability				
Low		1.00		1.00
Medium		**1.52**		**1.68 (*p*=0.068)†**
High		**2.08 (*p*=0.013)***		**1.62**
VISITATION				
How often visit green space				
<once a month				1.00
> once a month				**1.99**
>once a fortnight				**1.64**
> once a week				**1.85 (*p*=0.075)†**
Socio-demographic factors included in each model when significant associations (*p*≤0.250) identified through univariate analysis. Factors significant where p≤0.1 are shown in *italics*.	*Age, income,* education, *neighbourhood, time lived in neighbourhood, living arrangement, own or rent home*	*Gender*, age, cultural background, neighbourhood, *living arrangement, own or rent home, type of home*	*Gender, age,* income, education, time lived in neighbourhood, *living arrangement, own or rent home,* type of home	*Age, income,* education, neighbourhood, *living arrangement, own or rent home,* size of garden

* OR significant at 0.05 level † OR significant at 0.1 level