**Urban blue space and health and wellbeing in Hong Kong: Results from a survey of older adults**

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**Key messages**

* Few studies have examined the potential benefits of exposure to urban green and blue spaces for health and wellbeing in Asia. The current work looked at these issues, focusing especially on blue spaces such as beaches and coastal promenades, among a sample of predominantly older adults in Hong Kong.
* Frequent indirect exposure to blue spaces (sea views from home) was related to better self-reported general health using the SF1. Greater intentional exposure to blue spaces (recreational visit frequency), was associated with higher wellbeing using the WHO-5 Wellbeing Index
* Perceptions concerning the presence of wildlife and good outdoor facilities at local blue spaces were related to greater recreational visit frequency, while perceived safety and presence of wildlife were positively related to recalled wellbeing from a single visit. High-intensity activities and visit durations of one to two hours (relative to shorter visits) were also associated with higher experiential wellbeing

**Keywords:**

Blue Space, Health and Wellbeing; Hong Kong; Public health; Urban design.

**Abstract**

*Background*

Use of blue spaces such as coastlines, rivers and lakes, can mitigate some public health risks associated with rapid urbanisation. Few studies have been conducted in Asia which is home to more than 50% of the World’s population. The current research explored these issues in Hong Kong, a large, Asian metropolitan city.

*Methods*

The survey involved a cross-section of 1000 predominantly middle and older age adults attending a cancer screening programme. Blue space exposure was operationalised as 1) a view from home (indirect exposure), 2) commuting/travelling through blue space (incidental exposure); and, 3) visiting for recreation (intentional exposure). Outcome measures were self-reported health, subjective wellbeing, and experiential wellbeing during a single visit.

*Results*

Indirect exposure to blue spaces was associated with greater odds of self-reported 'good' health (OR= 1.7, 95% CIs 1.2-2.4), while intentional exposure was linked to greater odds of 'high' wellbeing (OR = 1.7, 95%CIs, 1.1-2.6). Visiting blue space more than once per week was more likely among those who lived within 10-15 mins walking distance (OR = 2.7, 95%CIs, 1.8-4.2), and believed the location had good facilities (OR = 2.0, 95 % CIs, 1.2-3.3) and more wildlife (ORadj = 1.6, 95% CIs, 1.1 -2.3). Greater odds of 'high' recalled wellbeing on blue space visits was evident for longer visits (OR = 1.9, 95%CIs, 1.1-3.1), and higher intensity activities (OR= 4.0, 95%CIs, 1.7-9.5).

*Conclusions*

Hong Kong’s blue spaces appear to be an important public health resource for key local populations. Research is needed to confirm the generalizability of findings to other population groups and to understand how this evidence could inform city planning for the benefit of public health.

**Introduction**

The number of people living in densely populated urban areas globally is increasing annually (United Nations, 2015). Despite numerous advantages to health and wellbeing (Dye, 2008; Godfrey and Julien, 2005), urbanisation also poses challenges to human health including air and water pollution and associated respiratory (Samet et al., 2000; Taylor et al., 2004; Tong and Chen, 2002), cardiovascular and gastro-intestinal illnesses (Brunekreef and Holgate, 2002). Densely populated urban areas can also be cognitively and emotionally stressful, undermining mental health and wellbeing (Gong et al., 2012; Peen et al., 2010). Depression, for instance, is predicted to be the leading cause of Disability Adjusted Life Years (DALYs) in middle to high income countries by 2030 (World Health Organization, 2004) with urbanisation playing an important role in this trend (Goryakin et al., 2017).

Elements of ‘natural environments’ within urban settings (e.g. parks) can, in part, mitigate some of these threats through improvements in air quality, encouraging physical activity and reducing stress (Hartig and Kahn, 2016; Hartig et al., 2014). People who live in urban areas with more green space tend to have: better self-reported health (Maas et al., 2006; Mitchell and Popham, 2007; Seresinhe et al., 2015); a lower risk of cardiovascular and respiratory illnesses (Alcock et al., 2017; Kardan et al., 2015; Maas et al., 2009), diabetes (Astell-Burt et al., 2014) and some cancers (Demoury et al., 2017); better mental health and wellbeing (Gascon et al., 2015; Mitchell et al., 2015; White et al., 2013b); better birth outcomes (Dadvand et al., 2012); and ultimately lower mortality risk (Gascon et al., 2016; James et al., 2016; Mitchell and Popham, 2008; Takano et al., 2002; Villeneuve et al., 2012).Evidence has also emerged that proximity to aquatic environments (‘blue spaces’ e.g. coastlines, lakes, rivers) may have similarly beneficial effects (Burkart et al., 2016; Gascon et al., 2017; Volker and Kistemann, 2011; Wheeler et al., 2012) especially for mental health and wellbeing (de Bell et al., 2017; de Vries et al., 2016; Nutsford et al., 2016; White et al., 2014).

However, associating objectively assessed green/blue space proximity, or area coverage, with health data tells us little about people’s actual use of these locations (Ekkel and de Vries, 2017). Simply living near them does not necessarily mean individuals visit or use them. Nor do we understand how they can be used to promote health and wellbeing (Chaix et al., 2013). Additionally, most research investigating blue space and health has been conducted in Europe, the US and Australia (Gascon et al., 2017) with few studies in regions such as Asia, despite being rapidly developing in terms of urbanisation. The aim of the current research was to address some of these issues using one of the world’s most densely populated coastal cities, Hong Kong. Similar to cities elsewhere, those living in the greenest areas have lower risk of mortality from a range of causes including cardiovascular disease, stroke and diabetes (Wang et al., 2017; Xu et al., 2017). However, we know of no research investigating blue space and psychological health in Hong Kong.

We focused on three key research questions. First, to what extent is self-reported general health and wellbeing in Hong Kong related to an individual’s exposure to the city’s blue spaces in terms of indirect (view from the home), incidental (work commute) and intentional (recreational visit) contact (Cox et al., 2017a; Cox et al., 2017b; Keniger et al., 2013)? Second, which environmental factors predict blue space visit frequency in Hong Kong (Arnberger and Eder, 2015; Koppen et al., 2014; Morris et al., 2011; Reynolds et al., 2007; Schipperijn et al., 2010)?Third, are some visit and environmental characteristics associated with better short-term recalled wellbeing outcomes (Shanahan et al., 2016; White et al., 2013c)? An overview of the research questions is provided in Figure 1.

[Figure 1 here]

**Method**

Participants

Ethical approval was provided by the Joint Chinese University of Hong Kong-New Territories East Cluster Clinical Research Ethics Committee (CREC) [Ref. no.: 2016.349]. Participants were 1000 adult Hong Kong residents who completed the survey voluntarily during visits to a community-based health centre for free-of-charge colorectal cancer (CRC) screening between December 2016 and June 2017. The following inclusion criteria were applied: (1) aged 18-70; (2) local resident; and (3) able to understand and complete the questionnaire independently.

The 1000 people were approximately evenly distributed with regard to sex (505 females; 493 males; 2 people did not say). The sample was not representative of Hong Kong’s population by age as 80% of respondents were >50 years old. However, an older adult sample is itself interesting because of research showing: a) the importance of mental health in older age (Chen et al., 2017; Jerkovic et al., 2017; Rosness et al., 2016); and b) the benefits of natural environments for older people (Moran et al., 2014).

Materials and methods

*Outcome variables*

For the first research question, the associations between blue space exposure and health were investigated for both self-reported i) general health and ii) wellbeing. Self-reported health (henceforth ‘health’) was assessed using the single-item ‘SF1’: ‘How is your health in general?’. Response options were: ‘Very bad’, ‘Bad’, ‘Fair’, ‘Good’ and ‘Very good’. Comparable measures predict mortality (Idler and Benyamini, 1997), have been positively associated with coastal proximity (White et al., 2013a), and are used internationally (European Social Survey, 2016). Following previous work (Wheeler et al., 2015), we dichotomised this variable into ‘Good’ (Good/Very good) and ‘Not good’ (Very bad/Bad/Fair) to account for the negative skew in responses (see Supplementary Table 1 for further explanation of all variables including variable manipulation). Our analysis thus predicted the likelihood of someone being in good vs. not good health, as a function of a variety of environmental and other predictors.

Wellbeing was assessed using the World Health Organisation’s 5 item Wellbeing Index (WHO-5)(Topp et al., 2015), which has been shown to be associated with reported green space access in Europe, for instance (Mitchell et al., 2015). Participants responded to five statements about their feelings during the past two weeks e.g. ‘*I have felt cheerful and in good spirits’* with response options ranging from ‘*At no time’* (numerical value = 0)to *‘All of the time’* (value = 5)(Supplementary Table 1). Response values were summed and multiplied by 4 to give a total wellbeing score out of 100 (Topp et al., 2015). Following (Gao et al., 2014), respondents were dichotomised into those with ‘High’ (≥50) vs. ‘Low’ (<50) wellbeing, for analytical purposes. An exploration of an alternative threshold reflecting ‘High’ (<28) vs. (Low ≥28) risk of depression (Löwe et al., 2004; Nicolucci et al., 2014) was conducted as a robustness check with details found in Supplementary Table 11.

For the third research question, recalled wellbeing was assessed for a specific visit to the respondent’s nearest blue space. A composite score (Cronbach’s alpha = 0.69, 95 % CI = 0.66 – 0.72) was calculated from responses to four items drawn from the English MENE survey (Natural England, 2017), which represent aspects of subjective wellbeing with the most academic and policy consensus (Kahneman et al., 1999; O'Donovan et al., 2017): ‘it made me feel happy’, ‘it made me feel anxious’ , ‘I found the visit worthwhile’ and ‘I was satisfied with the visit’, with seven-point response options from ‘strongly disagree’ (value= 1) to ‘strongly agree’ (value=7). This score was dichotomised such that mean values ≥6 were categorised as ’High’ experiential wellbeing’ and mean values <6 were ‘Low’ experiential wellbeing.

*Exposures*

Respondents were told that for the purposes of this survey ‘blue spaces’ included: inland aquatic areas (lakes, canals, rivers, fountains and pools), urban coastal areas (seaside resorts, harbours, ports and piers) and other coastal areas (beaches, cliffs and headlands). They were asked not to think about indoor locations (such as swimming pools), places visited as part of their job, or private locations such as within gardens or private pools. *Indirect exposure* was measured by asking whether the respondent had a view of blue space from their home (Nutsford et al., 2016). *Incidental exposure* was measured by asking “Do you usually pass by/through this blue space when commuting, to or from work/school/other daily activities?” (Honold et al., 2016). *Intentional exposure* was measured by asking participants how often they visited *any* blue spaces in the last four weeks. In addition to these three types of exposure, we included a simple measure of proximity to blue space: ‘Is this blue space within a 10-15 min walk from your home?’ (Schipperijn et al., 2010; Völker et al., 2018).

For the second and third research questions, participants were asked to focus specifically on the blue space *closest* to their home (and the one most likely to be visited frequently, Schipperijn et al., 2010). For this section intentional exposure was measured by asking participants how often they visited this particular blue space in the last four weeks. They were also asked to rate four characteristics of their nearest blue space: a) safety, b) presence of wildlife, c) whether it is generally free from litter and d) whether it has good facilities; on seven-point scales ranging from ‘strongly disagree’ to ‘strongly agree’ (Supplementary Table 2):.Respondents were asked to recall characteristics, including duration and the main activity, of the last time they visited this local blue space (Supplementary Table 3). Activity intensity was categorised according to the metabolic equivalent of task (MET) rate of the activities as in Elliott et al. (2015) (Supplementary Table 3).

Analyses controlled for a range of factors which may affect both health, wellbeing and/or visits to nature including age, income and occupation (see Supplementary Table 4 for full list; (Bijl et al., 2002; Nan et al., 2005; White et al., 2014). Respondents chose one of 18 districts as their home. There was a higher proportion of people living in Sha Tin in our sample than in Hong Kong as a whole. We therefore grouped location of residence as Hong Kong Island, Kowloon, New Territories excluding Sha Tin and Sha Tin as a separate district. (Supplementary Fig. 1). Measures of general physical functioning, recreational physical activity, and access to private outdoor spaces were also included. Due to the reciprocal relationship between self-reported health and wellbeing (Dolan et al., 2008), analysis of each variable (SF1 & WHO-5) controlled for the other. This was important to reduce the chances of any findings for both measures being due to the shared variance between them, and to ensure that any relationships to blue space spoke directly the unique variance of our respective target outcomes. Similarly, in our analysis of experiential well-being for specific visits, we controlled for WHO-5 responses to partial out general well-being levels. This increases confidence in any conclusion suggesting greater well-being on specific visits was due to the qualities of the environment, rather than being due to happier people visiting specific types of environment.

***Statistical Analysis***

Analyses were carried out in R (v3.4.0) (R Core Team, 2017). Unadjusted and adjusted logistic regressions were conducted for each outcome variable using a generalised linear modelling approach with a binomial error structure. Respondents with missing data were excluded. Model fit was estimated using the conservative Cox & Snell pseudo-*R*2 and the Akaike Information Criterion (AICc) which accounts for number of predictors (Akaike, 1974).

**Results**

*Exposure descriptives*

The number of respondents self-reporting good/not good health and high/low wellbeing as a function of blue space exposure is shown in Table 1. Blue space exposure was high among this sample: 39% had indirect exposure, 59% had incidental exposure, 38% had intentional exposure at least once a week, and 56% reported that a blue space was within a 10-15 minute walk of their home. A high proportion (70 %) of respondents recalled their most recent visit to their nearest blue space. Of those who provided a date for their visit (n = 463), 97 % were within four weeks. The median duration of these visits was 60 minutes (Supplementary Fig. 2), and the most frequent activity was ‘strolling’ (n = 387).

[Table 1 here]

*Research question 1: Blue space exposure, health and wellbeing*

Results for health and wellbeing as a function of blue space exposure can be seen in Table 2 (see Supplementary Table 6 for full models).

[Table 2 here]

*Self-reported health (Good vs. not good)*

Indirect blue space exposure (a view from the home) was associated with significantly higher odds of ‘good’ health in both the unadjusted and adjusted models (ORadj = 1.7, 95 % CI 1.2-2.4). There were no significant relationships with either intentional or incidental exposure to blue space, or walking distance, in either unadjusted or adjusted models. By contrast, visiting green spaces at least once a week (ORadj = 3.3, 95 % CI 1.5-7.0) and 1-2 visits in the last month (ORadj = 2.7, 95 % CI 1.3-5.7) were both associated with significantly higher odds of reporting good health in unadjusted and adjusted models. Figure 2a illustrates the strength of blue space exposure on self-reported health relative to selected covariates. The size of the association between health and indirect blue space exposure was similar to that between health and being male *vs.* female. Confidence in the overall results was gained from noting that, as might be expected, the strongest predictor of general health was the absence of restricted physical functioning. By themselves, the socio-demographic variables explained, 22% of the variation in health, with blue and green space variables explaining a further 2% (Supplementary Table 6).

[Figure 2 here]



*Subjective wellbeing (High vs. low)*

In contrast to self-reported health, intentional exposure (visiting blue space ≥ once a week), was positively associated with high wellbeing in both the unadjusted and adjusted models (ORadj = 1.7, 95 % CI, 1.1-2.6). The size of this association was similar to that between wellbeing and those who were retired *vs*. working full time (Figure 2b). Visiting blue space less often (once or twice a month) was significant only in the unadjusted model (ORadj = 1.4, 95 % CI, 1.0-2.1). Neither incidental nor indirect exposure, nor having a blue space within walking distance, were significant in either the unadjusted or adjusted models (Table 2). Visiting green space at least once a week was significant only in the unadjusted model, though individuals with access to private outdoor spaces were more likely to report high levels of wellbeing compared to those without (Figure 2b). By themselves, the socio-demographic variables explained 19% of the variation in wellbeing, with blue and green space variables explaining a further 1% (Supplementary Table 6). Of note, visiting blue space ≥ once a week, was also positively associated with wellbeing above the lower threshold set for depression risk (Supplementary Table 11, ORadj = 1.8, 95 % CIs, 1.0-3.1) suggesting potential clinical relevance.

*Research question 2: Intentional blue space exposure*

Using the results from question 1 to identify a threshold for wellbeing in relation to blue space visit frequency, we dichotomised intentional exposure into ‘≥ once a week’ and ‘< once a week’ (Supplementary Table 2).

Numbers of respondents self-reporting blue space exposure as a function of environmental characteristics are shown in Table 3. Intentional exposure was significantly positively related to indirect exposure (ORadj = 1.7, 95 % CI, 1.2-2.5), incidental exposure (ORadj = 3.0, 95 % CI, 2.0-4.5) and walking distance from home (ORadj = 2.7, 95%CIs, 1.8-4.2). Of the perceived local blue space qualities, agreement that the site had good facilities and wildlife were both significantly related to intentional blue space exposure in the unadjusted and adjusted models (facilities: ORadj = 2.0, 95 % CI, 1.2-3.3; wildlife: ORadj = 1.6, 95 % CI, 1.1 -2.3); with perceived safety only significantly associated in the unadjusted model. The effect size of facilities was similar to that for meeting recommended physical activity levels and the effect size for the presence of wildlife was similar to that of high income compared to low income (Figure 3; Supp. Table 8). The socio-demographic variables alone explained 15% of the variation in visit frequency, with nearby blue space variables explaining a further 13% (Table 4; Supplementary Table 8).

[Figure 3 here]



[Table 3 here]

[Table 4 here]

*Research question 3: Wellbeing on blue space visits*

Numbers of respondents self-reporting high/low recalled wellbeing as a function of visit characteristics are shown in Table 5. Compared to visits <30 minutes, a duration of 30-59 minutes was not significantly related to higher odds of recalled wellbeing (ORadj = 1.3, 95 % CI, 0.7-2.2). However, longer visits of 60-119 minutes (ORadj = 1.9, 95%CIs, 1.1-3.1) were associated with a significantly greater likelihood of high recalled wellbeing in both unadjusted and adjusted models (Fig. 4, Table 6). Visit durations of ≥120 minutes were significant only in the unadjusted model. Compared to a low intensity activity, taking part in a high intensity activity was also associated with significantly greater odds of high recalled wellbeing and resulted in the greatest effect size (ORadj = 4.0, 95%CIs, 1.7 - 9.5; Figure 4) while moderate intensity activity was not significant (ORadj = 1.3, 95 % CI 0.7 – 2.3). Both perceived safety (ORadj 2.1; 95% CI 1.4 – 3.2) and the presence of wildlife (ORadj=1.7, 95 % CI = 1.1 – 2.4) were associated with high recalled wellbeing, while neither presence of litter nor good facilities were significantly related. By themselves, the socio-demographic variables explained 8% of the variation, with visit characteristics explaining a further 8% (Table 6; Supplementary Table 9).



[Figure 4 here]

[Table 5 here]

[Table 6 here]

**Discussion**

*Summary of findings*

The current research is, we believe, the first to simultaneously examine how exposure to, and patterns of use of, urban blue spaces in a mega-city are related to self-reported health and wellbeing. It is also, as far as we are aware, the first study to explore these issues in an Asian setting. With respect to research question 1, the associations between health and wellbeing and blue space exposures, results were mixed. Simply having a view of blue space from the home (indirect exposure) was related to better self-reported health, and visiting blue spaces regularly for recreation (intentional exposure) was related to both better subjective wellbeing and a lower risk of depression. Both findings are consistent, at least in part, with results published elsewhere (de Vries et al., 2016; Gascon et al., 2017). For instance, spending time in blue spaces has been found to be particularly beneficial for psychological wellbeing in both Spain (Amoly et al., 2014) and the UK (MacKerron and Mourato, 2013). However, coastal views were associated with better mental health in Wellington, New Zealand (Nutsford et al., 2016) while we found an association only with general health in Hong Kong. Experimental research in mainland China has found that nature, and especially blue space views, could aid physiological stress recovery (Li and Sullivan, 2016; Wang et al., 2016) which may affect different aspects of health (Lin and Ensel, 1989). The mechanisms underlying these associations have yet to be elucidated.

Neither outcome was related to walking distance to the nearest blue space or incidental exposure (e.g. blue spaces as part of commutes). The former is particularly surprising given that most analyses assume home proximity is a sufficient measure of exposure for investigating health and wellbeing associations, including green spaces in Hong Kong and mainland China (Wang et al., 2017; Xu et al., 2017). Issues of objective *vs*. subjective proximity estimates notwithstanding (Macintyre et al., 2008), the current study suggests that home distance is a less sensitive proxy for blue space contact than intentional exposure.

That the associations remained after controlling for key socio-demographic factors such as age, occupation, marital status and income, suggests the relationships are potentially applicable to a wider cross-section of society. Each analysis also controlled for physical activity levels, suggesting that any benefits are not simply due to increased exercise (Richardson et al., 2013), but are likely due to other processes such as stress relief, attention restoration and social cohesion (Cox et al., 2017b; Markevych et al., 2017; Weinstein et al., 2015). We also controlled for the other health/wellbeing outcome variable in our models, demonstrating that these were unique contributions rather than simply reflections of the same underlying process. The effect sizes were as large as some of those from key socio-demographic variables which helps contextualise their importance in relation to policymaking choices.

Finally, although our focus was on blue spaces, we also included recreational use of green spaces to isolate the unique blue space contribution. Intriguingly, we found contrasting relationships between intentional exposures to green and blue space. There was a particularly strong relationship between green space visit frequency and health and yet we found it was unrelated to wellbeing. In contrast, visiting blue space was associated with wellbeing but was unrelated to general health. We suggest that visits to each provide a unique contribution to health and wellbeing and further work is needed to investigate the pathways of their respective contributions as well as their relative importance.

Results for the second research question, relating to predictors of intentional exposure to the nearest blue space, were clearer. Indirect exposure, incidental exposure and blue space within a 10-15 minute walk from home were all positively associated with visiting the nearest blue spaces for recreation (intentional exposure). In terms of quality, perceptions that their nearest blue space had good facilities and wildlife to see and enjoy predicted how often respondents used that blue space. This latter finding highlights the importance of good environmental quality in people’s willingness to visit blue space locations (De Vos et al., 2016). The lack of relationships with feelings of safety and incivilities, which had been found to be important in earlier studies (Calogiuri and Chroni, 2014), may be because the public spaces in this Asian city are typically clean and street crime in Hong Kong is generally low (Barnett et al., 2015; Bouhours and Broadhurst, 2015; Broadhurst et al., 2017).

Our final research question concerned whether certain characteristics of blue space visits were associated with recalled wellbeing. While perceived safety was not related to blue space visit frequency in the second research question, it was a predictor of recalled wellbeing during a single visit, along with presence of wildlife. Consistent with previous work, there was a positive association between duration and recalled wellbeing (van den Berg et al., 2016) although the current threshold of 60 minutes was higher than in some earlier studies (Barton and Pretty, 2010; Shanahan et al., 2016). Visits involving relatively high intensity activities were also more likely to be associated with a greater likelihood of reporting higher recalled wellbeing, again consistent with earlier work (MacKerron and Mourato, 2013). Controlling for general wellbeing suggests these effects are not merely the result of happier people being more likely to engage in more intense activities.

*Study Limitations*

Some limitations of this study should be addressed in future work. First, we recruited self-referred subjects who opted to join a screening programme and these individuals could be more health-conscious when compared with the general population. Our sample was also not representative of Hong Kong as a whole, in particular by age and home district. Hence, further studies are needed to explore the generalizability of our results, to the wider Hong Kong population. Nevertheless, findings were consistent with those from other studies in China (Ying et al., 2015), and studies using larger and more representative samples in other countries (de Vries et al., 2016; Wheeler et al., 2012) suggesting further research investment using a more systematic sampling approach is justified. Second, the cross-sectional nature of the data mean that causality cannot be assumed. Despite this, our results are consistent with both experimental (Li and Sullivan, 2016; Wang et al., 2016) and longitudinal (MacKerron and Mourato, 2013; White et al., 2013a) findings suggesting that the directionality inferred is more than possible. Third, we also recognise that surveys might not be able to comprehensively determine individuals’ lived experiences of blue spaces including their personal, historical and cultural significance. More qualitative work is therefore needed to explore these issues (Bell et al., 2015; Bell et al., 2018; Volker and Kistemann, 2013).

*Conclusions*

The current findings suggest that in Asian cities such as Hong Kong, maintaining public access to, and residential visibility of, waterfronts and other aquatic settings that are large enough to spend at least an hour in and which allow residents the opportunity to engage in high intensity activities, may offer important opportunities for protecting and promoting public health. While the current evidence suggests that potential benefits may already be experienced by those who regularly use these spaces, future work is needed to better understand how best to use this evidence to inform future urban planning and developments in the city. Our findings thus have potentially significant implications for the design of living environments that incorporate a public health perspective.

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Table 1: Number of respondents for each exposure and health outcome for research question 1. See supplementary table 5 for full table with all covariates

Note. Missing data means some group total Ns are <1000.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | Total | Total in regression sample |  Self-reported health\* |  WHO-5 Wellbeing Index\* |
| Exposure or accessibility | Good | Not good | High | Low |
| N | (%) | N | (%) | N | (%) | N | (%) | N | (%) | N | (%) |
| **Blue space**  |  |  |  |  |  |  |  |  |  |  |  |  |
| Indirect (view) |  |  |  |  |  |  |  |  |  |  |  |  |
|  *Yes*  | 390 | 39 | 368 | 38.45 | 150 | 40.76 | 218 | 59.24 | 232 | 63.04 | 136 | 36.96 |
|  *No (ref)* | 610 | 61 | 589 | 61.55 | 175 | 29.71 | 411 | 69.78 | 317 | 53.82 | 269 | 45.67 |
| Incidental (commute) |  |  |  |  |  |  |  |  |  |  |  |  |
|  *Yes* | 589 | 59 | 559 | 58.60 | 216 | 38.64 | 343 | 61.36 | 353 | 63.15 | 206 | 36.85 |
|  *No (ref)* | 408 | 41 | 395 | 41.40 | 109 | 27.59 | 286 | 72.41 | 196 | 49.62 | 199 | 50.38 |
| Intentional (visits) |  |  |  |  |  |  |  |  |  |  |  |  |
|  *≥1 a week* | 381 | 38 | 360 | 37.74 | 144 | 40.00 | 216 | 60.00 | 241 | 66.94 | 119 | 33.06 |
|  *1-2 a month* | 353 | 35 | 345 | 36.16 | 120 | 34.78 | 225 | 65.22 | 200 | 57.97 | 145 | 42.03 |
|  *Not at all (ref)* | 260 | 26 | 249 | 26.10 | 61 | 24.50 | 188 | 75.50 | 108 | 43.37 | 141 | 56.63 |
| Within walking distance |  |  |  |  |  |  |  |  |  |  |  |  |
|  *Yes* | 561 | 56 | 531 | 55.66 | 200 | 37.66 | 331 | 62.34 | 333 | 62.71 | 198 | 37.29 |
|  *No (ref)* | 439 | 44 | 423 | 44.34 | 125 | 29.55 | 298 | 70.45 | 216 | 51.06 | 207 | 48.94 |
| **Green space** (intentional) |  |  |  |  |  |  |  |  |  |  |  |  |
|  *≥1 a week* | 570 | 57 | 540 | 56.60 | 212 | 39.26 | 328 | 60.74 | 341 | 63.15 | 199 | 36.85 |
|  *1-2 a month* | 343 | 34 | 329 | 34.49 | 101 | 30.70 | 228 | 69.30 | 175 | 53.19 | 154 | 46.81 |
|  *Not at all (ref)* | 87 | 9 | 85 | 8.91 | 12 | 14.12 | 73 | 85.88 | 33 | 38.82 | 52 | 61.18 |
| \*These represent totals for regression modelling sample |

*Table 2:* Odds ratios (OR) and 95% Confidence Intervals (CIs) for unadjusted and adjusted results for research question 1: Health and wellbeing outcomes (ORs in Bold have lower bound CIs ≥1.0). Full model results in Supplementary Table 6

|  |  |  |  |
| --- | --- | --- | --- |
|  | Self-reported health outcome |  | WHO-5 Wellbeing Index outcome |
|  | Unadjusted |  | Adjusted |  | Unadjusted |  | Adjusted |
|  | OR | 95% CIs |  | OR | 95% CIs |  | OR | 95% CIs |  | OR | 95% CIs |
| **Exposures** |  |  |  |  |  |  |  |  |  |  |  |
| Indirect (View) |  |  |  |  |  |  |  |  |  |  |  |
|  *Yes* | 1.4\* | 1.0 – 1.9 |  | 1.7\*\* | 1.2 – 2.4 |  | 1.1 | 0.8 – 1.5 |  | 1.0 | 0.7 – 1.4 |
|  *No (ref)* | - | - |  | - | - |  | - | - |  | - | - |
| Incidental (Commute) |  |  |  |  |  |  |  |  |  |  |  |
|  *Yes* | 1.4 | 1.0 – 1.9 |  | 1.1 | 0.8 – 1.6 |  | 1.3 | 1.0 – 1.8 |  | 1.1 | 0.8 – 1.6 |
|  *No (ref)* | - | - |  | - | - |  | - | - |  | - | - |
| Intentional (Visits)  |  |  |  |  |  |  |  |  |  |  |  |
|  *≥1 a week* | 1.2 | 0.8 – 1.9 |  | 1.0 | 0.6 – 1.6 |  | 1.8\*\* | 1.2 – 2.7 |  | 1.7\* | 1.1 – 2.6 |
|  *1-2 a month* | 1.3 | 0.9 – 1.9 |  | 1.0 | 0.7 – 1.6 |  | 1.5\* | 1.1 – 2.2 |  | 1.4 | 1.0 – 2.2 |
|  *Not at all (ref)* | - | - |  | - | - |  | **-** | **-** |  | - | - |
| Walking distance |  |  |  |  |  |  |  |  |  |  |  |
|  *Yes* | 1.0 | 0.7 – 1.4 |  | 0.8 | 0.6 – 1.2 |  | 1.1 | 0.8 – 1.5 |  | 1.1 | 0.8 – 1.5 |
|  *No (ref)* | - | - |  | - | - |  | - | - |  | - | - |
| Green space visits  |  |  |  |  |  |  |  |  |  |  |  |
|  *≥1 a week* | 3.0\*\* | 1.5 – 6.0 |  | 3.3\*\* | 1.5 – 7.0 |  | 1.7\* | 1.0 – 2.8 |  | 1.3 | 0.7 – 2.3 |
|  *1-2 a month* | 2.2\* | 1.1 – 4.4 |  | 2.7\* | 1.3 – 5.7 |  | 1.3 | 0.8 – 2.2 |  | 1.1 | 0.6 – 1.9 |
| *Not at all (ref)* |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| **Covariates** |  |  |  |  |  |  |  |  |  |  |  |
| Other health/wellbeing outcome | NO |  |  | YES |  |  | NO |  |  | YES |  |
| *Socio-demographics* | NO |  |  | YES |  |  | NO |  |  | YES |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Intercept | -2.05 |  | -4.35 |  |  | -0.72 |  |  | -2.24 |  |
| N | 954 |  | 954 |  |  | 954 |  |  | 954 |  |
| AIC | 1211  |  | 1019.7 |  |  | 1270.30 |  | 1147.1 |
| Cox & Snell R2 (%) | 4.1 |  |  | 23.5 |  |  |  4.8 |  |  | 19.5 |  |
| OR = Odds Ratio. CI = Confidence Interval. \* p <.05; \*\* p <.01, \*\*\*p < 0.001 |

Table 3 Number of respondents for each covariate for research question 2 out of the total sample, regression modelling sample, those who visit their nearest blue space at least once a week and those who visit less often.. See supplementary table 7 for full table with all covariates

Note. Missing data means some group total Ns are <1000.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Total | Total in regression sample | Visit blue space >=1 a week\* | Visit blue space <1 a week\* |
|  | N | % | N | % | N | % | N | % |
| View |  |  |  |  |  |  |  |  |
|  *Yes* | 390 | 39.0 | 370 | 38.6 | 173 | 46.8 | 197 | 53.2 |
|  *No (ref)* | 610 | 61.0 | 589 | 61.4 | 108 | 18.3 | 481 | 81.7 |
| Commute |  |  |  |  |  |  |  |  |
|  *Yes* | 589 | 59.0 | 562 | 58.6 | 240 | 42.7 | 322 | 57.3 |
|  *No (ref)* | 408 | 41.0 | 397 | 41.4 | 41 | 10.3 | 356 | 89.7 |
| Walking distance |  |  |  |  |  |  |  |  |
|  *Yes* | 561 | 56.0 | 534 | 55.7 | 236 | 44.2 | 298 | 55.8 |
|  *No (ref)* | 439 | 44.0 | 425 | 44.3 | 45 | 10.6 | 380 | 89.4 |
| Safe |  |  |  |  |  |  |  |  |
|  *Agree* | 661 | 66.1 | 634 | 66.1 | 235 | 37.1 | 399 | 62.9 |
|  *Don’t agree (ref)* | 339 | 33.9 | 325 | 33.9 | 46 | 14.2 | 279 | 85.8 |
| Presence of wildlife |  |  |  |  |  |  |  |  |
|  *Agree* | 524 | 52.6 | 507 | 52.9 | 191 | 37.7 | 316 | 62.3 |
|  *Don’t agree (ref)* | 473 | 47.4 | 452 | 47.1 | 90 | 19.9 | 362 | 80.1 |
| Free from litter |  |  |  |  |  |  |  |  |
|  *Agree* | 453 | 45.4 | 440 | 45.9 | 160 | 36.4 | 280 | 63.6 |
|  *Don’t agree (ref)* | 545 | 54.6 | 519 | 54.1 | 121 | 23.3 | 398 | 76.7 |
| Good facilities |  |  |  |  |  |  |  |  |
|  *Agree* | 755 | 75.6 | 729 | 76.0 | 250 | 34.3 | 479 | 65.7 |
|  *Don’t agree (ref)* | 244 | 24.4 | 230 | 24.0 | 31 | 13.5 | 199 | 86.5 |
| \*Totals are given for regression modelling sample |

*Table 4: Odds ratios (OR) and 95% Confidence Intervals (CIs)* for unadjusted and adjusted models for research question 2: Intentional nearest blue space visit frequency (ORs in Bold have lower bound CIs ≥1.0). Full model results in Supplementary Table 8.

|  |  |  |
| --- | --- | --- |
| Variable | Unadjusted | Adjusted |
| OR | 95% CI | OR | 95% CI |
| Exposures |  |  |  |  |
| Indirect (view) |  |  |  |  |
|  *Yes* | 1.8\*\*\* | 1.3 - 2.6 | 1.8\*\* | 1.3 - 2.6 |
|  *No (ref)* |  |  |  |
| Incidental (commute) |  |  |  |
|  *Yes* | 3.4\*\*\* | 2.3 - 5.0 | 3.0\*\*\* | 2.0 - 4.5 |
|  *No (ref)* |  |  |  |
| Walking distance |  |  |  |
|  *Yes* | 3.0\*\*\* | 2.0 - 4.4 | 2.7\*\*\* | 1.8 - 4.2 |
|  *No (ref)* |  |  |  |
| Perceived qualities |  |  |
| Safe |  |  |  |  |
|  *Agree* | 1.7\* | 1.1 - 2.5 | 1.5 | 1.0 - 2.4 |
|  *Don’t agree (ref)* |  |  |  |
| Presence of wildlife |  |  |
|  *Agree* | 1.7\*\* | 1.2 - 2.4 | 1.6\* | 1.1 - 2.3 |
|  *Don’t agree (ref)* |  |  |  |
| Free from litter |  |  |  |
|  *Agree* | 1.2 | 0.9 - 1.7 | 1.1 | 0.8 - 1.6 |
|  *Don’t agree (ref)* |  |  |  |
| Good facilities |  |  |  |
|  *Agree* | 1.9\*\* | 1.2 - 3.1 | 2.0\*\* | 1.2 - 3.3 |
|  *Don’t agree (ref)* |  |  |  |
| **Covariates** |  |  |  |  |
| Self-reported health | NO |  | YES |  |
| *Socio-demographics* | NO |  | YES |  |
|  |  |  |  |  |
| Intercept | -4.03 |  | -5.25 |  |
| N | 959 |  | 959 |  |
| AIC | 920.95 |  | 895.17 |  |
| Cox & Snell pseudo-*R2* (%) | 23 |  | 28 |  |
| OR = Odds Ratio. CI = Confidence Interval. \* p <.05; \*\* p <.01, \*\*\*p < 0.001 |

*Table 5. Number of respondents for each variable for the total sample, sample used in regression analysis and for each of the outcome options for research question 3. See Supplementary Table 9 for full results including all covariates*

Note. Missing data means some group total Ns are <1000.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variables | Total | Total in regression sample | High wellbeing\* | Not high wellbeing\* |
|  | N | % | N | % | N | % | N | % |
| Duration |  |  |  |  |  |  |  |  |
|  *30 - <60 mins* | 162 | 23.8 | 152 | 23.5 | 87 | 57.2 | 65 | 42.8 |
|  *60 - <120 mins* | 226 | 33.1 | 218 | 33.7 | 148 | 67.9 | 70 | 32.1 |
|  *≥120 mins* | 173 | 25.4 | 160 | 24.8 | 103 | 64.4 | 57 | 35.6 |
|  *<30 mins (ref)* | 121 | 17.7 | 116 | 18.0 | 56 | 48.3 | 60 | 51.7 |
| Activity intensity |  |  |  |  |  |  |  |
|  *High* | 87 | 12.6 | 85 | 13.2 | 71 | 83.5 | 14 | 16.5 |
|  *Med* | 537 | 77.8 | 500 | 77.4 | 295 | 59.0 | 205 | 41.0 |
|  *Low (ref)* | 66 | 9.6 | 61 | 9.4 | 28 | 45.9 | 33 | 54.1 |
| Water contact |  |  |  |  |  |  |  |  |
|  *Yes* | 28 | 4.1 | 26 | 4.0 | 21 | 80.8 | 5 | 19.2 |
|  *No (ref)* | 662 | 95.9 | 620 | 96.0 | 373 | 60.2 | 247 | 39.8 |
| Safe |  |  |  |  |  |  |  |  |
|  *Agree* | 661 | 66.1 | 478 | 74.0 | 320 | 66.9 | 158 | 33.1 |
|  *Don’t agree (ref)* | 339 | 33.9 | 168 | 26.0 | 74 | 44.0 | 94 | 56.0 |
| Presence of wildlife |  |  |  |  |  |  |
|  *Agree* | 524 | 52.6 | 372 | 57.6 | 254 | 68.3 | 118 | 31.7 |
|  *Don’t agree (ref)* | 473 | 47.4 | 274 | 42.4 | 140 | 51.1 | 134 | 48.9 |
| Free from litter |  |  |  |  |  |  |  |  |
|  *Agree* | 453 | 45.4 | 321 | 49.7 | 210 | 65.4 | 111 | 34.6 |
|  *Don’t agree (ref)* | 545 | 54.6 | 325 | 50.3 | 184 | 56.6 | 141 | 43.4 |
| Good facilities |  |  |  |  |  |  |  |  |
|  *Agree* | 755 | 75.6 | 539 | 83.4 | 343 | 63.6 | 196 | 36.4 |
|  *Don’t agree (ref)* | 244 | 24.4 | 107 | 16.6 | 51 | 47.7 | 56 | 52.3 |
|  |  |  | \*Totals are given for regression modelling sample |

*Table 6: Odds ratios (OR) and 95% Confidence Intervals (CIs)* for unadjusted and adjusted models for research question 3: Wellbeing on specific visits (ORs in Bold have lower bound CIs ≥1.0). Full model results are given in Supplementary Table 10

|  |  |  |
| --- | --- | --- |
| Variables | Unadjusted | Adjusted |
|  | OR | 95% CI | OR | 95% CI |
| **Visit characteristics** |  |  |  |  |
| Duration |  |  |  |  |
|  *30 - <60 mins* | 1.3 | 0.8 - 2.2 | 1.3 | 0.7 - 2.2 |
|  *60 - <120 mins* | 1.9\*\* | 1.2 - 3.1 | 1.9\* | 1.1 - 3.1 |
|  *≥120 mins* | 1.7\* | 1.0 - 2.9 | 1.5 | 0.9 - 2.5 |
|  *<30 mins (ref)* |  |  |  |  |
| Activity intensity |  |  |  |  |
|  *High* | 4.3\*\*\* | 1.9 - 10.0 | 4.0\*\* | 1.7 - 9.5 |
|  *Med* | 1.5 | 0.8 - 2.6 | 1.3 | 0.7 - 2.3 |
|  *Low (ref)* |  |  |  |  |
| Water contact |  |  |  |  |
|  *Yes* | 1.2 | 0.4 - 3.8 | 1.2 | 0.4 -3.9 |
|  *No (ref)* |  |  |  |  |
| **Perceived qualities** |  |  |  |  |
| Safe |  |  |  |  |
|  *Agree* | 1.7\*\*\* | 1.5 - 3.2 | 2.1\*\*\* | 1.4 - 3.2 |
|  *Don’t agree (ref)* |  |  |  |
| Presence of wildlife |  |  |  |
|  *Agree* | 1.7\*\* | 1.2 - 2.4 | 1.7\*\* | 1.1 - 2.4 |
|  *Don’t agree (ref)* |  |  |  |
| Free from litter |  |  |  |
|  *Agree* | 1.2 | 0.8 - 1.7 | 1.1 | 0.8 - 1.6 |
|  *Don’t agree (ref)* |  |  |  |
| Good facilities |  |  |  |
|  *Agree* | 1.9 | 0.8 - 1.9 | 1.2 | 0.7 - 1.9 |
|  *Don’t agree (ref)* |  |  |  |
| **Covariates** |  |  |  |  |
| Wellbeing (WHO-5) | NO |  |  | YES |
| *Socio-demographics* | NO |  |  | YES |
|  |  |  |  |  |
| Intercept | -1.52 |  | -1.88 |  |
| N | 646 |  | 646 |  |
| AIC | 812.92 |  | 814.1 |  |
| Cox & Snell pseudo-*R2* (%) | 10.7 |  | 15.4 |  |
| OR = Odds Ratio. CI = Confidence Interval. \* p <.05; \*\* p <.01, \*\*\*p < 0.001 |

Akaike, H., 1974. A new look at the statistical model identification. IEEE transactions on automatic control 19, 716-723.

Alcock, I., White, M., Cherrie, M., Wheeler, B., Taylor, J., McInnes, R., im Kampe, E.O., Vardoulakis, S., Sarran, C., Soyiri, I., 2017. Land cover and air pollution are associated with asthma hospitalisations: A cross-sectional study. Environment international 109, 29-41.

Amoly, E., Dadvand, P., Forns, J., López-Vicente, M., Basagaña, X., Julvez, J., Alvarez-Pedrerol, M., Nieuwenhuijsen, M.J., Sunyer, J., 2014. Green and Blue Spaces and Behavioral Development in Barcelona Schoolchildren: The BREATHE Project. Environmental Health Perspectives 122, 1351-1358.

Arnberger, A., Eder, R., 2015. Are urban visitors’ general preferences for green-spaces similar to their preferences when seeking stress relief? Urban Forestry & Urban Greening 14, 872-882.

Astell-Burt, T., Feng, X., Kolt, G.S., 2014. Is neighborhood green space associated with a lower risk of type 2 diabetes? Evidence from 267,072 Australians. Diabetes Care 37, 197-201.

Barnett, A., Cerin, E., Ching, C.S.K., Johnston, J.M., Lee, R.S.Y., 2015. Neighbourhood environment, sitting time and motorised transport in older adults: a cross-sectional study in Hong Kong. Bmj Open 5, 11.

Barton, J., Pretty, J., 2010. What is the best dose of nature and green exercise for improving mental health? A multi-study analysis. Environmental science & technology 44, 3947-3955.

Bell, S.L., Phoenix, C., Lovell, R., Wheeler, B.W., 2015. Seeking everyday wellbeing: The coast as a therapeutic landscape. Soc. Sci. Med. 142, 56-67.

Bell, S.L., Westley, M., Lovell, R., Wheeler, B.W., 2018. Everyday green space and experienced well-being: the significance of wildlife encounters. Landscape Research 43, 8-19.

Bijl, R.V., de Graaf, R., Ravelli, A., Smit, F., Vollebergh, W.A.M., 2002. Gender and age-specific first incidence of DSM-III-R psychiatric disorders in the general population. Social Psychiatry and Psychiatric Epidemiology 37, 372-379.

Bouhours, B., Broadhurst, R., 2015. Violence Against Women in Hong Kong: Results of the International Violence Against Women Survey. Violence Against Women 21, 1311-1329.

Broadhurst, R., Lee, K.W., Chan, C.Y., 2017. Crime trends, Understanding criminal justice in Hong Kong, 2nd ed. Routledge, Oxford, New York, pp. 45-68.

Brunekreef, B., Holgate, S.T., 2002. Air pollution and health. Lancet 360, 1233-1242.

Burkart, K., Meier, F., Schneider, A., Breitner, S., Canário, P., Alcoforado, M.J., Scherer, D., Endlicher, W., 2016. Modification of heat-related mortality in an elderly urban population by vegetation (urban green) and proximity to water (urban blue): evidence from Lisbon, Portugal. Environmental health perspectives 124, 927.

Calogiuri, G., Chroni, S., 2014. The impact of the natural environment on the promotion of active living: an integrative systematic review. BMC Public Health 14, 873.

Chaix, B., Meline, J., Duncan, S., Merrien, C., Karusisi, N., Perchoux, C., Lewin, A., Labadi, K., Kestens, Y., 2013. GPS tracking in neighborhood and health studies: a step forward for environmental exposure assessment, a step backward for causal inference? Health Place 21, 46-51.

Chen, C.M., Lee, I.C., Su, Y.Y., Mullan, J., Chiu, H.C., 2017. The longitudinal relationship between mental health disorders and chronic disease for older adults: a population-based study. Int. J. Geriatr. Psychiatr. 32, 1017-1026.

Cox, D.T., Shanahan, D.F., Hudson, H.L., Fuller, R.A., Anderson, K., Hancock, S., Gaston, K.J., 2017a. Doses of nearby nature simultaneously associated with multiple health benefits. International journal of environmental research and public health 14, 172.

Cox, D.T.C., Shanahan, D.F., Hudson, H.L., Plummer, K.E., Siriwardena, G.M., Fuller, R.A., Anderson, K., Hancock, S., Gaston, K.J., 2017b. Doses of Neighborhood Nature: The Benefits for Mental Health of Living with Nature. Bioscience 67, 147-155.

Dadvand, P., Sunyer, J., Basagana, X., Ballester, F., Lertxundi, A., Fernández-Somoano, A., Estarlich, M., García-Esteban, R., Mendez, M.A., Nieuwenhuijsen, M.J., 2012. Surrounding greenness and pregnancy outcomes in four Spanish birth cohorts. Environmental health perspectives 120, 1481.

de Bell, S., Graham, H., Jarvis, S., White, P., 2017. The importance of nature in mediating social and psychological benefits associated with visits to freshwater blue space. Landsc. Urban Plan. 167, 118-127.

De Vos, A., Cumming, G.S., Moore, C.A., Maciejewski, K., Duckworth, G., 2016. The relevance of spatial variation in ecotourism attributes for the economic sustainability of protected areas. Ecosphere 7, e01207-n/a.

de Vries, S., ten Have, M., van Dorsselaer, S., van Wezep, M., Hermans, T., de Graaf, R., 2016. Local availability of green and blue space and prevalence of common mental disorders in the Netherlands. British Journal of Psychiatry Open 2, 366-372.

Demoury, C., Thierry, B., Richard, H., Sigler, B., Kestens, Y., Parent, M.-E., 2017. Residential greenness and risk of prostate cancer: A case-control study in Montreal, Canada. Environment international 98, 129-136.

Dolan, P., Peasgood, T., White, M., 2008. Do we really know what makes us happy? A review of the economic literature on the factors associated with subjective well-being. Journal of economic psychology 29, 94-122.

Dye, C., 2008. Health and Urban Living. Science 319, 766-769.

Ekkel, E.D., de Vries, S., 2017. Nearby green space and human health: Evaluating accessibility metrics. Landsc. Urban Plan. 157, 214-220.

Elliott, L.R., White, M.P., Taylor, A.H., Herbert, S., 2015. Energy expenditure on recreational visits to different natural environments. Soc. Sci. Med. 139, 53-60.

European Social Survey, 2016. ESS Round 8 Source Questionnaire, London: ESS ERIC Headquarters c/o City University London.

Gao, J., Weaver, S.R., Dai, J., Jia, Y., Liu, X., Jin, K., Fu, H., 2014. Workplace Social Capital and Mental Health among Chinese Employees: A Multi-Level, Cross-Sectional Study. PLOS ONE 9, e85005.

Gascon, M., Triguero-Mas, M., Martínez, D., Dadvand, P., Forns, J., Plasència, A., Nieuwenhuijsen, M.J., 2015. Mental health benefits of long-term exposure to residential green and blue spaces: a systematic review. International journal of environmental research and public health 12, 4354-4379.

Gascon, M., Triguero-Mas, M., Martínez, D., Dadvand, P., Rojas-Rueda, D., Plasència, A., Nieuwenhuijsen, M.J., 2016. Residential green spaces and mortality: a systematic review. Environment international 86, 60-67.

Gascon, M., Zijlema, W., Vert, C., White, M.P., Nieuwenhuijsen, M.J., 2017. Outdoor blue spaces, human health and well-being: A systematic review of quantitative studies. Int. J. Hyg. Environ. Health.

Godfrey, R., Julien, M., 2005. Urbanisation and health. Clinical Medicine 5, 137-141.

Gong, P., Liang, S., Carlton, E.J., Jiang, Q., Wu, J., Wang, L., Remais, J.V., 2012. Urbanisation and health in China. The Lancet 379, 843-852.

Goryakin, Y., Rocco, L., Suhrcke, M., 2017. The contribution of urbanization to non-communicable diseases: Evidence from 173 countries from 1980 to 2008. Econ. Hum. Biol. 26, 151-163.

Hartig, T., Kahn, P.H., 2016. Living in cities, naturally. Science 352, 938-940.

Hartig, T., Mitchell, R., de Vries, S., Frumkin, H., 2014. Nature and Health, in: Fielding, J.E. (Ed.), Annual Review of Public Health, Vol 35. Annual Reviews, Palo Alto, pp. 207-228.

Honold, J., Lakes, T., Beyer, R., van der Meer, E., 2016. Restoration in Urban Spaces: Nature Views From Home, Greenways, and Public Parks. Environment and Behavior 48, 796-825.

Idler, E.L., Benyamini, Y., 1997. Self-Rated Health and Mortality: A Review of Twenty-Seven Community Studies. Journal of Health and Social Behavior 38, 21-37.

James, P., Hart, J.E., Banay, R.F., Laden, F., 2016. Exposure to greenness and mortality in a nationwide prospective cohort study of women. Environmental health perspectives 124, 1344.

Jerkovic, O.S., Sauliune, S., Sumskas, L., Birt, C.A., Kersnik, J., 2017. Determinants of self-rated health in elderly populations in urban areas in Slovenia, Lithuania and UK: findings of the EURO-URHIS 2 survey. Eur. J. Public Health 27, 74-79.

Kahneman, D., Diener, E., Schwarz, N., 1999. Well-being: Foundations of hedonic psychology. Russell Sage Foundation.

Kardan, O., Gozdyra, P., Misic, B., Moola, F., Palmer, L.J., Paus, T., Berman, M.G., 2015. Neighborhood greenspace and health in a large urban center. Sci Rep 5, 11610.

Keniger, L.E., Gaston, K.J., Irvine, K.N., Fuller, R.A., 2013. What are the benefits of interacting with nature? International journal of environmental research and public health 10, 913-935.

Koppen, G., Sang, Å.O., Tveit, M.S., 2014. Managing the potential for outdoor recreation: Adequate mapping and measuring of accessibility to urban recreational landscapes. Urban forestry & urban greening 13, 71-83.

Li, D., Sullivan, W.C., 2016. Impact of views to school landscapes on recovery from stress and mental fatigue. Landsc. Urban Plan. 148, 149-158.

Lin, N., Ensel, W.M., 1989. Life Stress and Health: Stressors and Resources. American Sociological Review 54, 382-399.

Maas, J., Verheij, R.A., de Vries, S., Spreeuwenberg, P., Schellevis, F.G., Groenewegen, P.P., 2009. Morbidity is related to a green living environment. Journal of Epidemiology & Community Health 63, 967-973.

Maas, J., Verheij, R.A., Groenewegen, P.P., de Vries, S., Spreeuwenberg, P., 2006. Green space, urbanity, and health: how strong is the relation? J. Epidemiol. Community Health 60, 587-592.

Macintyre, S., Macdonald, L., Ellaway, A., 2008. Lack of agreement between measured and self-reported distance from public green parks in Glasgow, Scotland. Int. J. Behav. Nutr. Phys. Act. 5, 26.

MacKerron, G., Mourato, S., 2013. Happiness is greater in natural environments. Global Environmental Change 23, 992-1000.

Markevych, I., Schoierer, J., Hartig, T., Chudnovsky, A., Hystad, P., Dzhambov, A.M., de Vries, S., Triguero-Mas, M., Brauer, M., Nieuwenhuijsen, M.J., Lupp, G., Richardson, E.A., Astell-Burt, T., Dimitrova, D., Feng, X.Q., Sadeh, M., Standl, M., Heinrich, J., Fuertes, E., 2017. Exploring pathways linking greenspace to health: Theoretical and methodological guidance. Environmental Research 158, 301-317.

Mitchell, R., Popham, F., 2007. Greenspace, urbanity and health: relationships in England. Journal of Epidemiology & Community Health 61, 681-683.

Mitchell, R., Popham, F., 2008. Effect of exposure to natural environment on health inequalities: an observational population study. The Lancet 372, 1655-1660.

Mitchell, R.J., Richardson, E.A., Shortt, N.K., Pearce, J.R., 2015. Neighborhood environments and socioeconomic inequalities in mental well-being. Am J Prev Med 49, 80-84.

Morris, J., O'Brien, E., Ambrose-Oji, B., Lawrence, A., Carter, C., Peace, A., 2011. Access for all? Barriers to accessing woodlands and forests in Britain. Local Environment 16, 375-396.

Nan, L., Jeffrey, A.J., James, W.S., David, F., Stephen Joel, C., 2005. Self-Reported Health Status of the General Adult U.S. Population as Assessed by the EQ-5D and Health Utilities Index. Medical Care 43, 1078-1086.

Natural England, 2017. Monitor of Engagement with the Natural Environment The national survey on people and the natural environment: Technical Report to the 2009-16 surveys, <https://www.gov.uk/government/statistics/monitor-of-engagement-with-the-natural-environment-2015-to-2016>, p. 68.

Nutsford, D., Pearson, A.L., Kingham, S., Reitsma, F., 2016. Residential exposure to visible blue space (but not green space) associated with lower psychological distress in a capital city. Health & place 39, 70-78.

O'Donovan, G., Stensel, D., Hamer, M., Stamatakis, E., 2017. The association between leisure-time physical activity, low HDL-cholesterol and mortality in a pooled analysis of nine population-based cohorts. Eur. J. Epidemiol. 32, 559-566.

Peen, J., Schoevers, R.A., Beekman, A.T., Dekker, J., 2010. The current status of urban‐rural differences in psychiatric disorders. Acta Psychiatrica Scandinavica 121, 84-93.

R Core Team, 2017. R: A language and environment for statistical computing. , Vienna, Austria. <https://www.R-project.org/>.

Reynolds, K.D., Wolch, J., Byrne, J., Chou, C.-P., Feng, G., Weaver, S., Jerrett, M., 2007. Trail Characteristics as Correlates of Urban Trail Use. American Journal of Health Promotion 21, 335-345.

Richardson, E.A., Pearce, J., Mitchell, R., Kingham, S., 2013. Role of physical activity in the relationship between urban green space and health. Public health 127, 318-324.

Rosness, T.A., Strand, B.H., Bergem, A.L.M., Nafstad, P., Langballe, E.M., Engedal, K., Tambs, K., Bjertness, E., 2016. Association of psychological distress late in life and dementia-related mortality. Aging Ment. Health 20, 603-610.

Samet, J.M., Dominici, F., Curriero, F.C., Coursac, I., Zeger, S.L., 2000. Fine particulate air pollution and mortality in 20 US Cities, 1987-1994. N. Engl. J. Med. 343, 1742-1749.

Schipperijn, J., Ekholm, O., Stigsdotter, U.K., Toftager, M., Bentsen, P., Kamper-Jørgensen, F., Randrup, T.B., 2010. Factors influencing the use of green space: Results from a Danish national representative survey. Landsc. Urban Plan. 95, 130-137.

Seresinhe, C.I., Preis, T., Moat, H.S., 2015. Quantifying the impact of scenic environments on health. Sci Rep 5.

Shanahan, D.F., Bush, R., Gaston, K.J., Lin, B.B., Dean, J., Barber, E., Fuller, R.A., 2016. Health benefits from nature experiences depend on dose. Sci Rep 6, 28551.

Takano, T., Nakamura, K., Watanabe, M., 2002. Urban residential environments and senior citizens’ longevity in megacity areas: the importance of walkable green spaces. Journal of Epidemiology & Community Health 56, 913-918.

Taylor, S.L., Roberts, S.C., Walsh, C.J., Hatt, B.E., 2004. Catchment urbanisation and increased benthic algal biomass in streams: linking mechanisms to management. Freshw. Biol. 49, 835-851.

Tong, S.T.Y., Chen, W., 2002. Modeling the relationship between land use and surface water quality. Journal of Environmental Management 66, 377-393.

Topp, C.W., Østergaard, S.D., Søndergaard, S., Bech, P., 2015. The WHO-5 Well-Being Index: a systematic review of the literature. Psychotherapy and psychosomatics 84, 167-176.

United Nations, 2015. World Urbanization Prospects: The 2014 Revision, New York, p. 493.

van den Berg, M., van Poppel, M., van Kamp, I., Andrusaityte, S., Balseviciene, B., Cirach, M., Danileviciute, A., Ellis, N., Hurst, G., Masterson, D., Smith, G., Triguero-Mas, M., Uzdanaviciute, I., Wit, P.d., Mechelen, W.v., Gidlow, C., Grazuleviciene, R., Nieuwenhuijsen, M.J., Kruize, H., Maas, J., 2016. Visiting green space is associated with mental health and vitality: A cross-sectional study in four european cities. Health & Place 38, 8-15.

Villeneuve, P.J., Jerrett, M., Su, J.G., Burnett, R.T., Chen, H., Wheeler, A.J., Goldberg, M.S., 2012. A cohort study relating urban green space with mortality in Ontario, Canada. Environmental research 115, 51-58.

Völker, S., Heiler, A., Pollmann, T., Claßen, T., Hornberg, C., Kistemann, T., 2018. Do perceived walking distance to and use of urban blue spaces affect self-reported physical and mental health? Urban Forestry & Urban Greening 29, 1-9.

Volker, S., Kistemann, T., 2011. The impact of blue space on human health and well-being - Salutogenetic health effects of inland surface waters: A review. Int. J. Hyg. Environ. Health. 214, 449-460.

Volker, S., Kistemann, T., 2013. "I'm always entirely happy when I'm here!" Urban blue enhancing human health and well-being in Cologne and Dusseldorf, Germany. Soc. Sci. Med. 78, 113-124.

Wang, D., Lau, K.K.-L., Yu, R., Wong, S.Y.S., Kwok, T.T.Y., Woo, J., 2017. Neighbouring green space and mortality in community-dwelling elderly Hong Kong Chinese: a cohort study. BMJ Open 7.

Wang, X.X., Rodiek, S., Wu, C.Z., Chen, Y., Li, Y.X., 2016. Stress recovery and restorative effects of viewing different urban park scenes in Shanghai, China. Urban Forestry & Urban Greening 15, 112-122.

Weinstein, N., Balmford, A., DeHaan, C.R., Gladwell, V., Bradbury, R.B., Amano, T., 2015. Seeing community for the trees: The links among contact with natural environments, community cohesion, and crime. Bioscience 65, 1141-1153.

Wheeler, B.W., Lovell, R., Higgins, S.L., White, M.P., Alcock, I., Osborne, N.J., Husk, K., Sabel, C.E., Depledge, M.H., 2015. Beyond greenspace: an ecological study of population general health and indicators of natural environment type and quality. Int. J. Health Geogr. 14, 17.

Wheeler, B.W., White, M., Stahl-Timmins, W., Depledge, M.H., 2012. Does living by the coast improve health and wellbeing? Health & place 18, 1198-1201.

White, M.P., Alcock, I., Wheeler, B.W., Depledge, M.H., 2013a. Coastal proximity, health and well-being: results from a longitudinal panel survey. Health Place 23, 97-103.

White, M.P., Alcock, I., Wheeler, B.W., Depledge, M.H., 2013b. Would you be happier living in a greener urban area? A fixed-effects analysis of panel data. Psychological science 24, 920-928.

White, M.P., Pahl, S., Ashbullby, K., Herbert, S., Depledge, M.H., 2013c. Feelings of restoration from recent nature visits. Journal of Environmental Psychology 35, 40-51.

White, M.P., Wheeler, B.W., Herbert, S., Alcock, I., Depledge, M.H., 2014. Coastal proximity and physical activity: Is the coast an under-appreciated public health resource? Preventive medicine 69, 135-140.

World Health Organization, 2004. The global burden of disease: 2004 update, Geneva, Switzerland, p. 160.

Xu, L., Ren, C., Yuan, C., Nichol, J.E., Goggins, W.B., 2017. An Ecological Study of the Association between Area-Level Green Space and Adult Mortality in Hong Kong. Climate 5, 55.

Ying, Z., Ning, L.D., Xin, L., 2015. Relationship Between Built Environment, Physical Activity, Adiposity, and Health in Adults Aged 46–80 in Shanghai, China. Journal of Physical Activity and Health 12, 569-578.