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

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ABSTRACT

The potential benefits of aquatic environments for public health have been understudied in Asia. We investigated the relationships between blue space exposures and health outcomes among a sample of predominantly older adults in Hong Kong. Those with a view of blue space from the home were more likely to report good general health, while intentional exposure was linked to greater odds of high wellbeing. Visiting blue space regularly was more likely for those within a 10–15 min walk, and who believed visit locations had good facilities and wildlife present. Longer blue space visits, and those involving higher intensity activities, were associated with higher recalled wellbeing. Our evidence suggests that, at least for older citizens, Hong Kong's blue spaces could be an important public health resource.

1. Introduction

Globally, the number of people living in densely populated urban areas is increasing annually (United Nations, 2015). Despite numerous advantages to health and wellbeing (Dye, 2008; Godfrey and Julien, 2005), this growth of urban living, or urbanisation, also poses challenges to human health including air and water pollution and associated respiratory (Liu et al., 2017; Samet et al., 2000; Taylor et al., 2004; Tong and Chen, 2002), cardiovascular (Mustafić et al., 2012) and gastro-intestinal illnesses (Brunekreef and Holgate, 2002; McLellan et al., 2018). 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., 2014a) 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, termed 'blue space' in this paper (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).

Three main pathways linking green spaces to good health have been proposed (Markevych et al., 2017): reducing environmental harms (e.g. mitigating noise pollution; Gascon et al., 2018), supporting emotion regulation and the restoration of depleted cognitive capacities (e.g. through stress alleviation; Ward Thompson et al., 2012), and building capacities (e.g. through supporting physical activity; Astell-Burt et al., 2014b). Similarly, blue spaces may be able to confer benefits through such mechanisms: reducing harm (e.g. by mitigating heat-related

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mortality; Burkart et al., 2016), restoring capacities (e.g. through relieving stress; White et al., 2013c), and building capacities (e.g. through supporting health-enhancing physical activity; Elliott et al., 2015).

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 green and blue spaces can be best 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 rapid urbanisation. The aim of the current research was to address some of these issues, in particular the paucity of research on this topic in Asia and the use of spatial measures rather than actual use, for one of the world's most densely populated coastal cities, Hong Kong. Similar to cities elsewhere, those living in the greenest areas of Hong Kong 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? We explore three different types of exposures: indirect (view from the home), incidental (work commute) and intentional (recreational visit) contact (Cox et al., 2017a, 2017b; Keniger et al., 2013). Second, which environmental factors predict blue space visit frequency in Hong Kong? Environmental characteristics of nature have been found to be related to visit frequency around the world (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, as also has been found elsewhere (Shanahan et al., 2016; White et al., 2013c)? An overview of the research questions is provided in Fig. 1.

2. Method

2.1. Location

Hong Kong is a unique location within which to study nature interactions and health and wellbeing. It is one of the most densely populated countries in the world; the district Kwun Tong is the densest with 57,250 people per square km (Census and Statistics Dept, 2015). However, there is also much countryside and 40% is designated as country park or special area for nature conservation (Agriculture Fisheries and Conservation Department, 2016). Hong Kong consists of

multiple islands and there is a wide range of aquatic environments including urban waterfronts; fountains and ponds in parks; inland rivers, waterfalls and reservoirs; as well as beaches and bays. Aquatic areas of specific interest include a UNESCO Global Geopark, Hong Kong Wetland Park and several marine parks.

2.2. 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 a convenience sample of 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. Participants were informed in writing (in traditional Chinese) of the nature of the study and gave their signed consent as approved by the ethics committee. 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 for quality of life 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, for example in encouraging physical activity and reducing mortality risk (Astell-Burt et al., 2014b; Moran et al., 2014; Sulander et al., 2016).

2.3. 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). As a result of the very low sample sizes in some categories ("Very bad" n = 2; "Very good" n = 26) and negative skew, we followed previous research in this area (Wheeler et al., 2012), and dichotomised this variable into 'Good' (Good/Very good) and 'Not good' (Very bad/Bad/

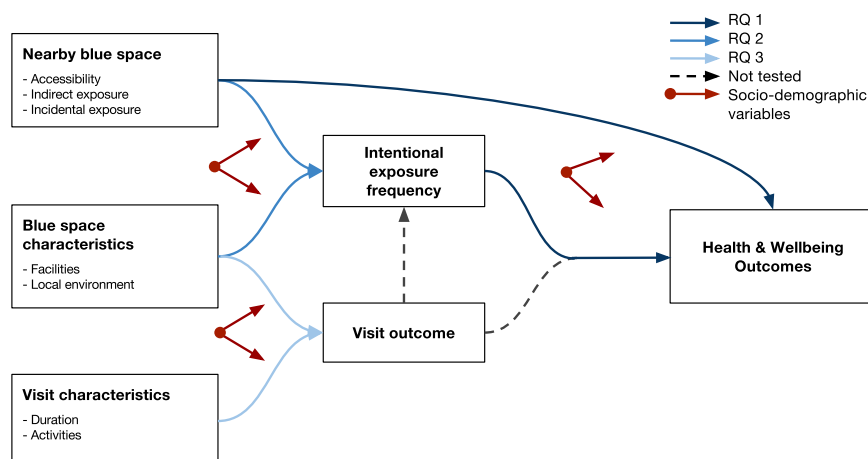


Fig. 1. Schematic of research questions (RQ) and analysis.

Fair) (see [Supplementary Table 1](#) for further explanation of all variables). 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.

Subjective wellbeing was assessed using the World Health Organisation's 5 item Wellbeing Index (WHO-5), a measure of overall psychological wellbeing ([Linton et al., 2016](#); [Topp et al., 2015](#)), which has been shown to be associated with reported green space access in Europe (e.g. [Mitchell et al., 2015](#)). Participants responded to five statements about their feelings during the past two weeks: 'I have felt cheerful and in good spirits', 'I have felt calm and relaxed', 'I have felt active and vigorous', 'I woke up feeling fresh and rested' and 'My daily life has been filled with things that interest me' with response options ranging from 'At no time' (numerical value = 0) to 'All of the time' (value = 5) ([Supplementary Table 1](#)). These items have been confirmed to each measure a unique dimension ([Blom et al., 2012](#); [Lucas-Carrasco et al., 2012](#); [Topp et al., 2015](#)). The WHO-5 correlates with measures of depression, psychological distress and suicide ([Garland et al., 2018](#); [Thelin et al., 2017](#); [Sisask et al., 2008](#); [Topp et al., 2015](#)). Response values were summed and multiplied by 4 to give a total wellbeing score out of 100 (Cronbach's alpha = 0.89, 95% CI = 0.88–0.90) ([Topp et al., 2015](#)). Different thresholds for the WHO-5 Wellbeing Index have been proposed. Key thresholds include: a score of ≥ 50 , considered to represent 'high' wellbeing (compared to < 50 representing 'low' wellbeing), and a score of < 28 suggesting a person is at 'high risk' of depression (compared to those with ≥ 28 who are at 'low risk'; [Löwe et al., 2004](#); [Nicolucci et al., 2014](#)). Although we explored both thresholds in the current work the main text focuses on the 'positive' outcome of high vs. low wellbeing (details of the 'negative' outcome, or risk of depression, robustness check can be 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 bespoke composite score (Cronbach's alpha = 0.69, 95% CI = 0.66–0.72) was calculated from responses to four items drawn from the English Monitor of Engagement with the Natural Environment (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](#)). These were: 'it made me feel happy' and 'it made me feel anxious' together representing positive and negative experiential wellbeing; 'I found the visit worthwhile' reflecting eudaimonic wellbeing; and 'I was satisfied with the visit' representing evaluative wellbeing. There were seven response options from 'strongly disagree' (value = 1) to 'strongly agree' (value = 7). Responses were left-skewed, therefore the score was also dichotomised for analysis. Mean values ≥ 6 were categorised as 'High recalled wellbeing' and mean values < 6 were 'Low recalled wellbeing'. We chose the value of 6 because it a) included those respondents who typically responded with "Agree" or "Strongly agree" to each question and b) resulted in appropriate sample sizes for each group (high $n = 420$; low $n = 280$).

2.4. 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 [the nearest] 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 their nearest 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 therefore 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 (examples given: parking, footpaths, toilets); on seven-point scales ranging from 'strongly disagree' (1) to 'strongly agree' (7) ([Supplementary Table 2](#)). No examples were provided for wildlife, though in this instance the most common species visible from above the waterline in coastal areas would be marine birds, and black kites which are a common sight along Hong Kong's coastline. Respondents were asked to recall characteristics, including duration and the main activity, of the most recent visit ([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](#)). The variable "water contact" categorised visits as having either direct contact with the water (swimming, fishing or on a boat/ferry) or not (e.g. walking on the beach).

Analyses controlled for a range of factors which may affect 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, we categorised these into four groups to account for low sample sizes in some districts (e.g. Central and Western district, Hong Kong Island $n = 8$). 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. These potential confounders have been found to be related to health and wellbeing ([Awata et al., 2007](#); [Fonta et al., 2017](#); [Mammen and Faulkner, 2013](#); [McMahon et al., 2017](#); [Nielsen and Hansen, 2007](#); [Poitras et al., 2016](#)). Furthermore, with regard to physical functioning, visits to the coast have been found to be more likely if respondents did not have an illness or disability ([White et al., 2014](#)). 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 resulting from the shared variance between them, and to ensure that any relationships to blue space reflected 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.

2.5. 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](#)).

Table 1

Number of respondents for each exposure and health outcome for RQ1 (Hong Kong, Dec 2016 – June 2017) (Supplementary Table 5 for full counts).

Exposure or accessibility	Total		Total in regression sample		Self-reported health ^a				WHO-5 Wellbeing Index ^a			
					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

^a These represent totals for regression modelling sample.

3. Results

3.1. Research question 1: blue space exposure, health and wellbeing

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 (full counts in Supplementary Table 5). 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 min 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 min (Supplementary Fig. 2), and the most frequent activity was ‘strolling’ ($n = 387$).

Statistical results for health (self-reported health) and wellbeing outcomes (WHO-5) as a function of the various blue space exposures can be seen in Table 2. We present results for models both unadjusted and adjusted for sociodemographics and other variables (see Supplementary Table 6 for full model results; including all covariates).

3.1.1. 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 ($OR_{adj} = 1.7$, 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 ($OR_{adj} = 3.3$, 95% CI 1.5–7.0) and 1–2 visits in the last month ($OR_{adj} = 2.7$, 95% CI 1.3–5.7) were both associated with significantly higher odds of reporting good health in unadjusted and adjusted models. Fig. 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 (and significant) 2% (Supplementary Table 6; Likelihood ratio test, $p = 0.003$).

3.1.2. Subjective wellbeing (high vs. low)

In contrast to self-reported health, intentional exposure (visiting blue space \geq once a week), was positively associated with high wellbeing in both the unadjusted and adjusted models ($OR_{adj} = 1.7$, 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 (Fig. 2b). Visiting blue space less often (once or twice a month) was significant only in the unadjusted model ($OR_{adj} = 1.4$, 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 (Fig. 2b). By themselves, the socio-demographic variables explained 19% of the variation in wellbeing, with blue and green space exposures explaining a further significant 1% (Supplementary Table 6; Likelihood ratio test, $p = 0.025$). Of note, visiting blue space \geq once a week, was also positively associated with a lower risk of depression (Supplementary Table 11, $OR_{adj} = 1.8$, 95% CIs, 1.0–3.1) suggesting potential clinical relevance.

3.2. Research question 2: intentional blue space exposure

Using the results from research question 1 to identify a threshold for wellbeing in relation to blue space visit frequency, we dichotomised intentional exposure into ‘ \geq 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 (Supplementary Table 7). Intentional exposure was significantly positively related to indirect exposure ($OR_{adj} = 1.7$, 95% CI, 1.2–2.5), incidental exposure ($OR_{adj} = 3.0$, 95% CI, 2.0–4.5) and walking distance from home ($OR_{adj} = 2.7$, 95% CI, 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: $OR_{adj} = 2.0$, 95% CI, 1.2–3.3; wildlife: $OR_{adj} = 1.6$, 95% CI, 1.1–2.3). 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 vs. low income (Fig. 3; Supplementary Table 8). Perceived safety was significant only in the unadjusted model and presence of litter was not significant in

Table 2

Odds ratios (OR) and 95% Confidence Intervals (CIs) for unadjusted and adjusted results for RQ1 (Hong Kong, Dec 2016–June 2017) (Supplementary Table 6 for full model results).

	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 R ² (%)	4.1		23.5		4.8		19.5	

OR = Odds Ratio. CI = Confidence Interval. ***p < 0.001.

* p < 0.05.

** p < 0.01.

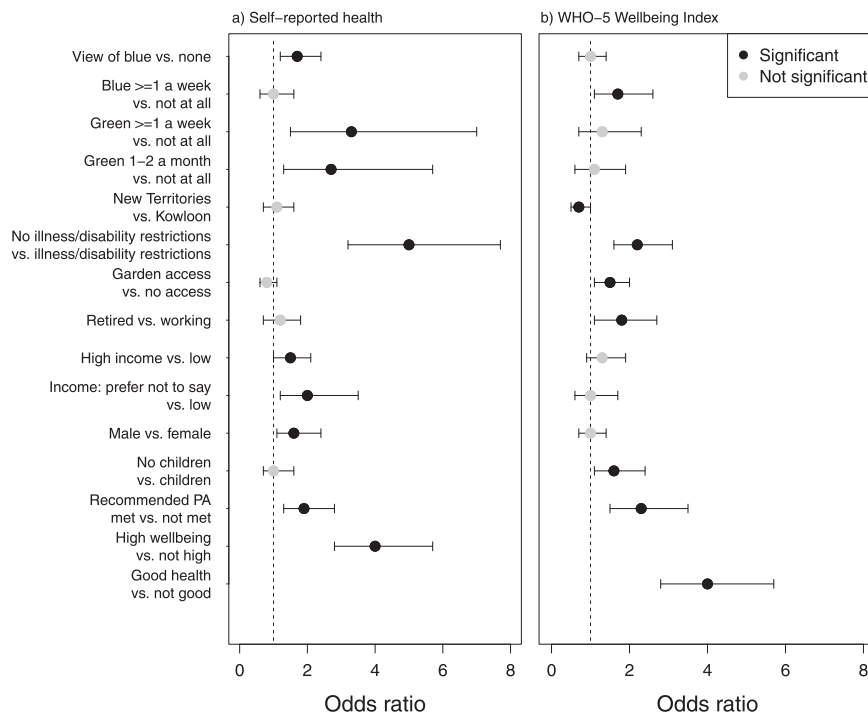


Fig. 2. Odds ratios and 95% confidence intervals for the adjusted model for a) ‘Good’ self-reported health and b) ‘High’ wellbeing for research question 1.

Table 3
Number of respondents for each predictor for RQ2 (Hong Kong, Dec 2016–June 2017) (Supplementary Table 7 for full counts).

	Total		Total in regression sample		Visit blue space > = 1 a week ^a		Visit blue space < 1 a week ^a	
	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

^a Totals are given for regression modelling sample.

Table 4
Odds ratios (OR) and 95% Confidence Intervals (CIs) for unadjusted and adjusted models for RQ2 (Hong Kong, Dec 2016–June 2017) (Supplementary Table 8 for full model results).

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-R ² (%)	23		28	

OR = Odds Ratio. CI = Confidence Interval.

* p < 0.05.
** p < 0.01.
*** p < 0.001.

3.3. 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 (Supplementary Table 9). The most common visit duration category was between 60 and 120 min. Most visits were of medium activity intensity (or moderate, n = 537) with fewer of either high or low intensity (high, or vigorous, n = 87; low, or light, n = 66). There were also very few visits which were categorised as having water contact (n = 28).

Compared to visits < 30 min, a duration of 30–59 min was not significantly related to higher odds of recalled wellbeing (OR_{adj} = 1.3, 95% CI, 0.7–2.2). However, longer visits of 60–119 min (OR_{adj} = 1.9, 95% CI, 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 min 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 (OR_{adj} = 4.0, 95% CI, 1.7–9.5; Fig. 4) while moderate intensity activity was not significant (OR_{adj} = 1.3, 95% CI 0.7–2.3). Water contact was not significant in either unadjusted or adjusted models. Both perceived safety (OR_{adj} 2.1; 95% CI 1.4–3.2) and the presence of wildlife (OR_{adj} = 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. Socio-demographic variables explained 8% of the variation, with visit characteristics explaining a further (significant) 8% (Table 6; Supplementary Table 10; Likelihood ratio test, p < 0.001).

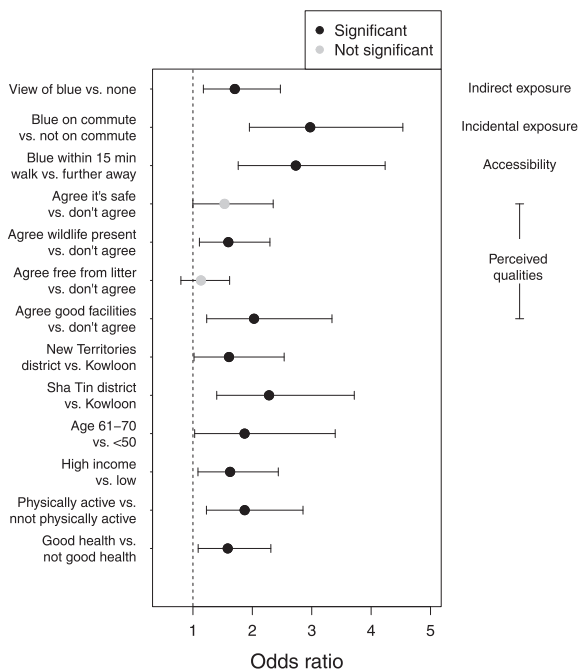


Fig. 3. Odds ratios and 95% confidence intervals for the adjusted model for factors affecting nearest blue space visit frequency (research question 2).

either unadjusted or adjusted models (Table 3). Socio-demographic variables explained 15% of the variation in visit frequency, with nearby blue space variables explaining a further (significant) 13% (Table 4; Supplementary Table 8; Likelihood ratio test, p < 0.001).

Table 5
Number of respondents for each predictor for RQ3 (Hong Kong, Dec 2016–June 2017) (Supplementary Table 9 for full counts).

Variables	Total		Total in regression sample		High wellbeing ^a		Not high wellbeing ^a	
	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

^a Totals are given for regression modelling sample.

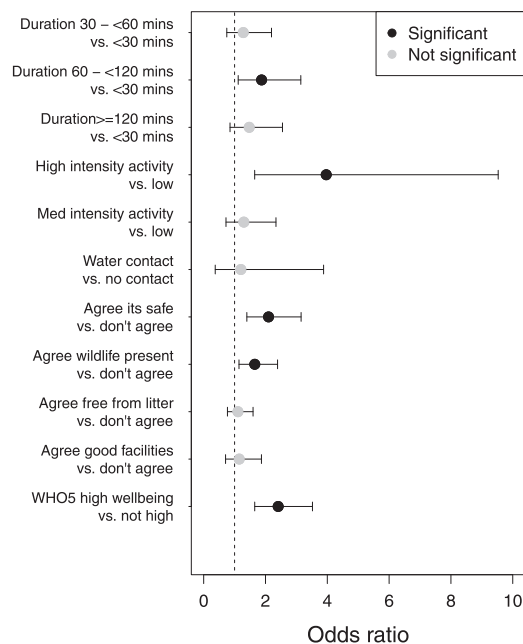


Fig. 4. Odds ratios and 95% confidence intervals for the adjusted model for factors affecting the wellbeing outcome from a single visit (research question 3).

4. Discussion

4.1. Summary of findings

The current research is, we believe, the first to simultaneously examine how exposure to, and 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 varied according to exposure type. 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 (de Bell et al., 2017; 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) although the mechanisms underlying these associations have yet to be elucidated. A view of the sea, and other natural environments, was associated with reduced annoyance from road noise in Hong Kong (Leung et al., 2017) which may represent one such pathway.

Neither outcome was related to walking distance to the nearest blue space or incidental exposure (blue spaces as part of commutes). The former is particularly surprising given that many 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 proximity may be a less sensitive proxy for blue space contact than intentional exposure. Alternatively, this lack of relationship between walking distance to blue spaces and health outcomes may be affected by characteristics of Hong Kong, such as the presence of an excellent public transport system, including a well-integrated metro, bus and ferry system, which would not necessarily be replicated in other large cities with less developed transport infrastructures. Of note however, Völker et al. (2018) also find that while perceived walking distance and blue space use were significantly related in a cross-sectional survey in two German cities, when blue

Table 6
Odds ratios (OR) and 95% Confidence Intervals (CIs) for unadjusted and adjusted models for RQ3 (Hong Kong, Dec 2016–June 2017) (Supplementary Table 10 for full model results).

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-R ² (%)	10.7		15.4	

OR = Odds Ratio. CI = Confidence Interval.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

space use and perceived walking distance were included as predictors in the same model, blue space use attenuated the effect of perceived walking distance. They therefore also suggest that perceived walking distance may not be an appropriate metric when assessing health outcomes in relation to blue space (specifically inland waters).

That the associations between blue space exposures and self-reported health and wellbeing remained after controlling for key socio-demographic factors such as age, occupation 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). Water has previously been found to be important in perceived restorativeness of scenes (White et al., 2010) and, in comparison with other environment types, coastal visits were associated with greatest restoration from recent nature visits (White et al., 2013c). Such processes are important for mental health and wellbeing, for example, stress reduction was found to mediate the relationship between streetscape greenery and mental health in the Netherlands (de Vries et al., 2013). 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. We found a particularly strong relationship between green space visit frequency and health and yet we found it was unrelated to wellbeing. Previous studies have found relationships between visiting green space and measures of both health (in terms of mortality; Sulander et al., 2016) and mental health (van den Berg et al., 2016). However, in their study investigating 'green' space visits and mental health, van den Berg et al. (2016) included water bodies in their definition of green spaces which may have obscured any unique salutogenic effect of water bodies. In contrast, we find visiting blue space was associated with wellbeing but was unrelated to general health. Similarly, Völker et al. (2018) also found that blue space use was related to mental health and unrelated to physical health in a survey in one German city. 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.

For the second research question, we found that indirect exposure, incidental exposure and blue space within a 10–15 min walk from home were all positively associated with visiting the nearest blue space for recreation (intentional exposure). In terms of quality, perceptions that their nearest blue space had good facilities and wildlife to see 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. Previous research spanning survey, experimental and field work in Europe and Hong Kong has also highlighted the importance of both wildlife and facilities in relation to nature visits (Lee and Davey, 2015; McCormack et al., 2010; Schipperijn et al., 2010; Veitch et al., 2012; Wan and Shen, 2015; White et al., 2017). The lack of relationships between blue space visit frequency and perceptions of safety or incivilities, which had been found to be important in earlier studies (Calogiuri and Chroni, 2014), may be because the public spaces in Hong Kong are typically clean and street crime in Hong Kong is generally low (Barnett et al., 2015; Bouhours and Broadhurst, 2015; Broadhurst et al., 2017). For instance, safety was also not found to be important by users of green spaces in Hong Kong (Wan and Shen, 2015).

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. Perceived species richness was found to be related to self-reported wellbeing in river side locations in Sheffield, UK (Dallimer et al., 2012). 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 min 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.

4.2. 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 generalisability 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., 2015) 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 complement both experimental findings between views of nature and health (Li and Sullivan, 2016; Wang et al., 2016) and within person findings between blue space visits and wellbeing (MacKerron and Mourato, 2013), 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, 2018; Volker and Kistemann, 2013).

4.3. Conclusions

In summary, in a sample of predominantly older adults in Hong Kong, those who visit blue spaces regularly were more likely to have good mental wellbeing and those who had a view of blue space from their residence were more likely to report good general health. People were more likely to visit Hong Kong's blue spaces if they felt there were good facilities and wildlife to see. Finally, both duration and activity intensity were found to be related to the recalled wellbeing outcome from a single visit along with perceived safety and presence of wildlife.

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. Despite the high availability of blue spaces in Hong Kong, over a quarter of our sample said they never visited blue space for recreation. Further, as the results are cross-sectional, research is also needed to find out if interventions within blue spaces, such as improvements to facilities or biodiversity, would encourage current non-visitors to visit and result in even greater population level gains in mental wellbeing. Our findings thus have potentially significant implications for the design of living environments that incorporate a public health perspective.

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Declarations of interest

None.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.healthplace.2018.11.003](https://doi.org/10.1016/j.healthplace.2018.11.003).

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