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Urban Characteristics Influencing Health of Older People: What Matters

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Abstract

Background: *Most studies examining the impact of the physical environment on health outcomes have been carried out in urban cities in the United States, Europe, or Australia, where population density and building architecture may be quite distinct from densely populated Asian cities. This study examines characteristics of urban environment in two highly contrasting regions of Hong Kong, exploring the effects of population and building density, accessible micro environment, air pollution, and social deprivation on health outcomes, using an ecological design.*

Methods: *A convenience sample of residents aged 60 years and older was carried out between July and December 2015. Data for four contrasting districts were examined based on differences in population density and urban development. Self-rated health and loneliness were used as health outcome indicators. Socio-demographic and geographic characteristics, air quality, health service provision, and social vulnerability of districts were documented. Spearman rank correlation was used to analyze the association between the different factors and health outcomes.*

Results: *Univariate correlation shows that self-rated health was poorer among the older age group, women, and in areas with greater population density and building height, poorer air quality, and higher prevalence of social vulnerability. Self-rated health was positively associated with a higher sky view factor, more open spaces and vegetation, more hospitals and hospital beds, and ambient ozone. Loneliness was inversely associated with education levels although the association was weak.*

Conclusion: *In densely populated cities such as Hong Kong, design of health-promoting urban environments for ageing populations should consider building density, height, and green spaces, as well as provision of health services, in order to contribute to health equity.*

Keywords: ***Self-rated health; loneliness; age-friendly city; open space; air pollution; social vulnerability; building density; health services.***

1. Introduction

Worldwide, there is a trend of people moving to urban areas as they age, presumably due to better access to various services and transport network. In the past decade there is increasing interest in studying the role of the urban environment in contributing to health and disease, to identify risk or protective factors to inform development of health promotion policies.[1] Information relating to older people are particularly pertinent in view of declining physical and cognitive functioning, as a result of the aging process itself or increasing prevalence of chronic disease. To respond to this challenge, the World Health Organization has drawn attention to the importance of making cities 'age-friendly', with a 2007 report identifying characteristics of 'age-friendly' cities under eight domains, based on focus groups with older people from 33 cities in 22 countries.[2] This initiated a world-wide Age Friendly Cities movement, with cities submitting plans to the WHO to be included in a list of 500 age-friendly cities. In parallel, there has been a growing academic discourse on the topic of 'age-friendly' cities, examining the overall concept as well as individual components. Recent research has examined age friendly cities and communities around the world, exploring 'age-friendly' characteristic and identifying challenges to sustainability. According to Buffel and Phillipson,[3] there is a need to combine the conceptual model of age friendly cities with an analysis of economic and social forces transforming urban environments for long term sustainability.

In a review of international literature on characteristics of 'age-friendly' communities, Lui et al.[4] refer to efforts to present ageing as a positive process and emphasize the active roles that older people can play, and to policies leading to social inclusion, engagement, and community development. They highlight the importance of physical and social environments, including housing and urban planning that affect health outcomes. Although the health effects of housing improvements have been difficult to demonstrate in a systematic review,[5] a recent study showed that housing type (public versus private) may impact health when adjusting for confounding factors.[6] Other than housing, the design of urban environments may influence health through promotion of physical activity. For example, a review of 14 studies found that increased physical activity is associated with net residential density, intersection density, public transport density, and number of parks. There was approximately a 50% difference in attaining a physical activity goal of 150 minutes per week between the most and least age-friendly neighbourhoods.[7] Urban design may also impact health through conceptualizations of personal space, which may restrict or enhance opportunities for new forms of personal identity and social engagement.[8] Indeed studies of neighbourhoods show that urban design has impact on social networks, social engagements, and social cohesion. These in turn affect well-being of older adults in the community.[9-11] The vulnerability of an individual to the adverse impact of these factors on well-being may be collectively expressed as social vulnerability.[12]

Studies examining the impact of the physical environment on older people's health outcomes have largely been carried out in urban cities in the United States, Europe, or Australia, where population density and building architecture may be quite different from densely populated Asian cities. In one recent Korean study,[13] there was an association between built environment and moderate to vigorous activity among Korean adults, with lower levels of physical activity found in urban environments. However, few physical environmental variables were examined. Few studies examined how urban design, such as building density, building height, sky view factor, open spaces and vegetation, air quality, and availability of health services may affect well-being of older people, using outcome measures that encompasses both physical and psychological health. It is recognized that the concept of health covers the broad interconnected dimensions of physical, mental and social well-being.[14] The commonly used summary indicator of health outcome in epidemiological studies is self-rated health, which incorporates psychological elements other than presence or absence of diseases.[15-17] Increasingly loneliness is being recognized as an important psychological state that also impacts on physical health, in increasing the risk of many chronic diseases,[1,18] the prevalence being up to 30% among older people in China and Japan.[19,20]

Hong Kong, a special administrative region of China situated on the Southern coast, is one of the most densely populated cities in the world. Over 7 million people occupy an area of 1,070 square kilometres, in which built-up urban areas account for less than 300 square kilometres. Within this living space there is great diversity in urban characteristics, as a result of different stages of urban development between older and newer districts. This diversity offers a natural 'laboratory' setting in which to examine the impact of different physical urban environments on the well-being of older people. This paper examines characteristics of urban environment in two highly contrasting regions of Hong Kong, characterized by significant differences in population and building density, age of buildings, accessible micro environments, air pollution and social vulnerability; and seeks to relate these features to physical and psychological well-being of older people using an ecological design making use of some data available from a territory-wide survey of age-friendly characteristics of Hong Kong.

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2. Materials and Methods

This survey was carried out between July and December 2015, and consisted of a convenience sample of residents in two highly contrasting regions, consisting of two districts that are densely populated (Kowloon City and Kwun Tong) and two less densely populated districts in the New Territories (Shatin and Tai Po). The respondents were aged 60 years and over.

The two health outcomes assessed in this study were self-rated health and loneliness. Self-rated health was assessed using the question, “How would you rate your overall health at the present time?” on a five-point Likert scale ranging from 1 (poor) to 5 (excellent). Responses were grouped into two categories: poor/fair and good/very good/excellent. Loneliness was assessed by a single item derived from the Center for Epidemiologic Studies Depression Scale (CES-D): “During the past week, have you felt lonely?” The response categories were 1 (rarely or none of the time, e.g. less than 1 day), 2 (some or a little of the time, e.g. 1 to 2 days), 3 (occasionally or a moderate amount of time, e.g. 3 to 4 days), and 4 (all of the time, e.g. 5 to 7 days). Responses were grouped into two categories: rarely/none of the time/some or little of the time, and occasionally or moderate amount of time/all of the time.[21]

Four contrasting districts were examined based on differences in population density and different stages of development. Socio-demographic factors, geographic characteristics, air quality, health service provision, and social vulnerability of the districts were documented. This study was carried out following the rules of the Declaration of Helsinki of 1975, revised in 2008. All participants gave written consent and the study was approved by the Clinical Research Ethics Committee of the Chinese University of Hong Kong.

The addresses of the participants were geocoded to enable calculation of geographic characteristics: building height, building coverage, sky view factor, open space, and green space. Building height and building coverage were calculated using building shapefiles containing the height and ground footprint of the buildings in Hong Kong obtained from the Planning Department. The height of buildings was extracted and converted into raster format using Geographic Information System (GIS) software. Based on district boundaries, the mean and standard deviation of building height were calculated for each district. The percentage of land covered by building footprint was also calculated. Sky view factor, an indicator of the compactness of the urban environment, was calculated by using the building height and footprint information.[22] To assess open space, information of land utilization in Hong Kong was obtained from the Planning Department. The proportion of land use ‘open space’ was calculated for each district based on district boundaries. In addition, the place of residence of respondents was geocoded in GIS and based on geocoded information, the proportion of ‘open space’ within a 1-km radial buffer was calculated for each respondent. Assessment of green space was based on the Normalized Difference Vegetation Index, an indicator to vegetation on the land surface. This was estimated from spectral information obtained from IKONOS satellite images, and the proportion of vegetation was calculated for each district based on district boundaries. Based on the geocoded information for respondents’ place of residence, the proportion of vegetation within a 1-km radial buffer was calculated for each respondent. Air quality was assessed based on air pollution data.

The district-level average of ozone, particulate matter with a diameter of ≤ 10 µm (PM_{10}), particulate matter with a diameter of ≤ 2.5 µm ($PM_{2.5}$), sulphur dioxide (SO_2), and oxides of nitrogen (NOX and NO_2) for Sha Tin, Tai Po, Kwun Tong, and Kowloon City in 2015 were obtained from the Environmental Protection Department.[23] All concentration units are in microgram per cubic metre ($\mu g/m^3$).

To assess the provision of health services, the number of hospitals and hospital beds for each district were retrieved from government sources.

The Social Vulnerability Index (SVI) was developed to determine the relative social vulnerability of older populations in every geographic unit in Hong Kong (i.e., constituency areas (CA) of the 18 district councils). The development of the SVI has been described elsewhere.[24] The SVI contains seven domains covering older population size, institutionalization, poverty, living alone, disability, communication obstacles, and access to primary care. This provides each CA with a SVI score ranging from 1 to 10, with higher scores representing higher social vulnerability.

2.1 Statistical methods

All statistical analyses were performed using the statistical package SAS, version 9.4 (SAS Institute, Inc., Cary, NC). Characteristics and health outcomes were compared for the four districts. Analysis of variance (ANOVA) was applied for continuous variables and Chi square test for categorical variables. Multiple comparisons were carried out using Least Significance Difference (LSD). Spearman rank correlation was used to analyze the association between the different factors and health outcomes adjusting for age.

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Table 1: Comparison of health outcomes and selected district characteristics by district

	Mean (SD)/ Percentage			
	Shatin (1)	**Tai Po (2)**	**Kwun Tong (3)**	**Kowloon City (4)**
Outcomes				
Self-rated health, %[a]	n=364	n=355	n=414	n=413
Poor/fair	57.42%	53.52%	65.94% [1,2]	64.89% [1,2]
Good/very good/excellent	42.58%	46.48%	34.06%	35.11%
Loneliness, %[b]	n=66	n=37	n=64	n=60
Rarely/none of the time/some or little of the time	68.18%	59.46%	60.94%	66.67%
Occasionally or moderate amount of time/all of the time	31.82%	40.54%	39.06%	33.33%
Potential predictors				
Socio-demographic factors				
Age in years, mean (SD)[a]	72.07 (7.77)	71.20 (7.13)	73.14 (7.32) [1,2]	72.66 (7.70) [2]
Female, %[a]	56.04%	53.24%	67.15% [1,2]	70.7% [1,2]
Primary education or below, % [a]	53.85%	53.52%	60.87% [1,2]	56.93%
Land-based non-institutional population (2016), n*	659,794	303,926	648,541	418,732
Proportion of older persons aged 65y+ (2016), %*	15.9%	15.2% [1]	17.2% [1,2]	15.3% [1,3]
Population density, number of persons per km^2 (2016), n*	9,602	2,233	57,530	41,802
Geographical characteristics				
Building height of the district in metres, mean (SD)	26.8 (30)	15.1 (18.7)	36.4 (33.7)	25.7 (22.5)
Building density of the district				
Building coverage of the district, %	4.7%	1.8%	19.8% [2]	19.4% [2]
Sky view factor of the district, mean	0.81	0.88	0.67	0.71
Proportion of open spaces at radius 1km, % [a]	7.8%	6.8%	5.5%	6.8%
Proportion of open spaces of the district, %	13.3%	10.1%	2.4% [1,2]	2.8% [1,2]
Proportion of vegetation at radius 1km, % [a]	36.7%	48.3% [1]	29.8% [1,2]	6.4% [1,2,3]
Proportion of vegetation of the district, %	79.0%	83.9% [1]	25.2% [1,2]	10.8% [1,2,3]
Air quality				
Selected pollutants in $\mu g/m^3$, annual mean[†]				
Ozone	48	49	46	NA
PM_{10}	34	36	44	NA
$PM_{2.5}$	24	23	27	NA
SO_2	8	6	8	NA
NO_X	59	55	101	NA
NO_2	41	37	55	NA
Health services provision				
Number of key services per 100,000 population, ratio				
HA hospitals and institutions	0.61	0.65	0.16	0.49
HA hospital beds^	347.9	506.3 [1]	218.8 [1,2]	340.4 [2,3]
Social vulnerability				
SVI, mean (SD)	3.56 (1.31)	5.98 (1.31) [1]	5.68 (1.31) [1]	6.10 (1.07) [1]
Proportion of CA with higher SVI (≥6), %	2.8	52.6 [1]	52.9 [1]	59.1 [1]

p-value<0.05 for [1] comparing (2), (3) or (4) with (1), [2] comparing (3) or (4) with (2), [3] comparing (4) with (3)

NA, Not available; HA, Hospital Authority; PM_{10}, Particulate matter with a diameter of 10 µm or less; $PM_{2.5}$, Particulate matter with a diameter of 2.5 µm or less; SO_2, Sulphur Dioxide; NO_X, Nitrogen oxide; NO_2, Nitrogen dioxide; SVI, Social Vulnerability Index; CA, Constituency area

[a]Data were extracted from the territory-wide survey of age-friendly characteristics (respondents aged 60y+). Proportions of open spaces, vegetation and standard deviation of building height were calculated based on 1km radius around the residential address of respondent

[b]Data were extracted from the territory-wide telephone survey (respondents aged 60y+)

**Figures were obtained from the Census and Statistics Department (2016 Population By-census)*

^Provision of health care by the HA as of 2012 – 2013

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[†]*Figures were obtained from the Environmental Protection Department (Annual Air Quality Monitoring Results 2015). All concentration units are in microgram per cubic metre (µg/m³)*

Table 2: Spearman's correlation coefficients between self-rated health, loneliness, and other variables

	Correlation coefficient (p-value)	
	Self-rated health[a] (n=1546)	Loneliness[b] (n=227)
Socio-demographic factors		
Age in years	-0.094 (0.0002)[a]	0.132 (0.0468)[b]
Gender	-0.227 (<.0001)[a]	-0.002 (0.9780)[b]
Education	0.217 (<.0001)[a]	-0.143 (0.0308)[b]
Land-based non-institutional population*	-0.023 (0.3736)	-0.023 (0.7336)
Population density*	-0.118 (<.0001)	0.075 (0.2624)
Geographical characteristics		
Building height of the district in metres	-0.066 (0.0089)	0.049 (0.4631)
Building density of the district		
Building coverage of the district	-0.118 (<.0001)	0.075 (0.2624)
Sky view factor of the district	0.118 (<.0001)	-0.075 (0.2624)
Open spaces of the district	0.101 (<.0001)	-0.090 (0.1788)
Vegetation of the district	0.128 (<.0001)	-0.035 (0.6049)
Air quality		
Selected pollutants in µg/m³[†]		
Ozone	0.118 (<.0001)	-0.079 (0.3108)
PM_{10}	-0.086 (0.0040)	0.107 (0.1699)
PM_{25}	-0.118 (<.0001)	0.079 (0.3108)
SO_2	-0.089 (0.0027)	0.014 (0.8574)
NO_X	-0.118 (<.0001)	0.079 (0.3108)
NO_2	-0.118 (<.0001)	0.079 (0.3108)
Health services provision		
HA hospitals and institutions	0.118 (<.0001)	-0.075 (0.2624)
HA hospital beds^	0.118 (<.0001)	-0.075 (0.2624)
Social vulnerability		
SVI	-0.048 (0.0611)	0.024 (0.7232)
CA with higher SVI (≥6)	-0.110 (<.0001)	0.049 (0.4591)

HA, Hospital Authority; PM_{10}, Particulate matter with a diameter of 10 µm of less; $PM_{2.5}$, Particulate matter with a diameter of 2.5 µm of less; SO_2, Sulphur Dioxide; NO_X, Nitrogen oxide; NO_2, Nitrogen dioxide; SVI, Social Vulnerability Index; CA, Constituency area

[a]*Data were extracted from the territory-wide survey of age-friendly characteristics (respondents aged 60y+)*

[b]*Data were extracted from the territory-wide telephone survey (respondents aged 60y+)*

**Figures were obtained from the Census and Statistics Department (2016 Population By-census)*

^Provision of health care by the HA as of 2012 – 2013

[†]*Figures were obtained from the Environmental Protection Department (Annual Air Quality Monitoring Results 2015). All concentration units are in microgram per cubic metre (µg/m³)*

3. Results

The health outcomes, socio-demographic factors, geographic characteristics, air quality, health services provision and social vulnerability for the four districts are shown in Table 1. There is a marked difference in population density between the four districts, with the two older districts (Kwun Tong and Kowloon City) having a five to six fold greater density compared with the newer district (Shatin) and twenty fold higher density compared with Tai Po (a rural area that has become urbanized since early

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1980s). This is also reflected in the greater building density and height, lower availability of open spaces, and (to a smaller extent) poorer air quality. The socio-demographic profile also differs between these districts: more women, a greater proportion of people aged 65 years and over, and those with lower education reside in the older districts of Kwun Tong and Kowloon City. The latter district also had a greater proportion of CA with higher SVI. A higher proportion of those residing in the older districts reported poorer self-rated health, but the prevalence of those reporting loneliness was not significantly different between the four districts.

Univariate Spearman rank correlation shows that self-rated health was poorer with increasing age and among women, and in areas with greater population density and building height, poorer air quality (higher PM_{10}, $PM_{2.5}$, SO_2, NOX and NO_2), and higher prevalence of social vulnerability (Table 2). Having a higher sky view factor, more open spaces and vegetation, more hospitals and hospital beds, and ambient ozone were associated with better self-rated health. Loneliness was inversely associated with education levels, although the association was weak.

4. Discussion

The findings of this study underscore the importance of urban physical and environments (in addition to age and socio-economic factors) on the well-being of older people. The results are particularly important for Hong Kong, which is one of the most densely populated cities in the world and also has the longest life expectancy for men and women.[25] Furthermore, the study findings highlight the fact that within a highly urbanized city, there remains much heterogeneity between constituent districts. This is of importance to ongoing urban planning associated with the continuing development of new districts to accommodate a growing ageing population.

Few studies examining the impact of physical environments have used self-rated health as an outcome, using individual as well as district level data. Self-rated health is a summary indicator of health that is frequently used in epidemiological studies and predicts future disability and mortality.[15-17] Furthermore it does not only reflect the burden of actual diseases but incorporates psychosocial dimensions in taking into account an individual's perspective of their physical health. A previous study in Hong Kong related premature mortality to the type of housing. Whereas many studies found a negative impact of public housing on health indicators, presumably because public housing is an indicator of lower socio-economic status, in Hong Kong public housing may have a protective effect on community health after controlling for local deprivation and neighborhood characteristics.[6] This study examined the physical nature of buildings and their environments rather than the nature of the housing type, since public housing is subsidized by the government and may be accompanied by greater accessibility to various services as well as social cohesion that counter the negative effects of low socio-economic status.

Other studies examined physical activity or walkability as a surrogate of health, relating this to open space or green space.[7,26] A Korean ecological study showed that there is an association between open spaces and moderate to vigorous physical activity in adults, although the effect of the built environment is relatively weak in comparison to individual socio-demographic correlates, contributing only 9.7% of the total variance.[13] Studies in Canada and the US examined the perception of the physical environment rather than objective measurements.[27,28]. One study using an objective neighbourhood assessment instrument in 777 neighbourhoods and 30,000 residents aged 18+ years in South Wales found that poor neighbourhood quality characterized by vandalism, crime and poor upkeep of properties were associated with poor self-rated health after adjusting for individual characteristics and area deprivation. However no association with green space was found.[29] A four cities study in Europe with diverse geographic, climatic and societal characteristics examining the impact of neighbourhood green space on self-rated physical and mental health showed that a positive association only existed among individuals with low levels of education in highly urbanized areas.[30]. However these studies did not over sample the older population, which are largely characterized by retirement from the work force and declining levels of physical and cognitive functioning, and therefore more susceptible to environmental impact.

The observation of lower levels of air pollutants (with the exception of ozone) being associated with better self-rated health is compatible with the findings of a recent systematic review showing that higher nitric oxide levels are associated with increased hospital admissions for respiratory diseases, the association being stronger in Southern China compared with the North, due in part to the greater elderly population with increased susceptibility in the South.[31] The findings with respect to ozone is the reverse compared with other pollutant, since ozone level tends to be higher in less dense areas, presumably there is more sunlight in less dense areas and ozone is formed in the presence of sunlight. The health impact of ozone may be less since there is low penetration indoors, unlike particulate matters. Possible mediators for associations with green space include better air quality as a result of vegetation, increase in physical activity, and possible psychological effects.[30]

There are several limitations in this cross sectional ecological study. The four contrasting districts selected for

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this study are mainly on level ground, and exclude districts that include islands, as these would include too many confounding geographic factors. Individual level data collected were limited to age, gender, and education level, and no individual lifestyle information such as physical activity was collected. Socio-economic information is represented by district level social vulnerability index. The study did not assess microclimatic factors such as urban heat island effects due to the presence of urban structures and corresponding higher temperature in urban areas.[22,32] More accurate information about urban green space can also be used as technological advances in remote sensing techniques allow more sophisticated calculations which produce higher-resolution vegetation data.[33] The cross sectional design may not take into account day-to-day variations, for self-rated health or loneliness. Furthermore the study cannot determine whether exposure to these neighbourhood characteristics predict poor outcomes in later life. There are limitations in the health outcome measurements. Self-rated health may not accurately reflect the presence or absence of individual diseases, while the use of one item measure from the CES-D may not be a reliable measure of loneliness.

In spite of these limitations, the strengths of this study lies in the inclusion of a wide range of physical and social environment variables to examine the impact on self-rated health and the psychosocial component represented by loneliness, taking into account demographic and socio-economic factors and health service provision.

This study provides new insights that are relevant to the design of health-promoting urban environments for ageing populations, taking into account building density, height, green spaces and air quality, as well as provision of health services. It shows that in achieving health equity, targeting social determinants alone may not be sufficient and that efforts should include a focus on physical environmental factors. Documentation of these associations in this hypothesis generating observational pilot study highlight the need for future purpose designed research to examine the impact of urban design on well-being of older people covering physical, psychological and social dimensions.

5. Conclusion

In densely populated cities such as Hong Kong, design of health-promoting urban environments for ageing populations should consider building density, height, and green spaces, as well as provision of health services, in order to contribute to health equity.

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