The association between distance to public amenities and cardiovascular risk factors among lower income Singaporeans

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ABSTRACT

Existing evidence on the association between built environment and cardiovascular disease (CVD) risk factors focused on the general population, which may not generalize to higher risk subgroups such as those with lower socio-economic status (SES). We examined the associations between distance to 5 public amenities from residential housing (public polyclinic, subsidized private clinic, healthier eatery, public park and train station) and 12 CVD risk factors (physical inactivity, medical histories and unhealthy dietary habits) among a study sample of low income Singaporeans aged ≥ 40 years (N = 1972). Using data from the Singapore Heart Foundation Health Mapping Exercise 2013–2015, we performed a series of logistic mixed effect regressions, accounting for clustering of respondents in residential blocks and multiple comparisons. Each regression analysis used the minimum distance (in km) between residential housing and each public amenity as an independent continuous variable and a single risk factor as the dependent variable, controlling for demographic characteristics. Increased distance (geographical inaccessibility) to a train station was significantly associated with lower odds of participation in sports whereas greater distance to a subsidized private clinic was associated with lower odds of having high cholesterol diagnosed. Increasing distance to park was positively associated with higher odds of less vegetable and fruits consumption, deep fried food and fast food consumption in the preceding week/month, high BMI at screening and history of diabetes, albeit not achieving statistical significance. Our findings highlighted potential effects of health-promoting amenities on CVD risk factors in urban low-income setting, suggesting gaps for further investigations.

1. Introduction

Cardiovascular disease (CVD) is the leading cause of morbidity and mortality worldwide, accounting for almost half of all non-communicable disease deaths (Laslett et al., 2012). Poor lifestyle behaviors (Cahill et al., 2014) such as physical inactivity and consumption of unhealthy diet are well known CVD risk factors that could lead to obesity and many associated diseases such as heart attack.

Adherence to healthy lifestyle has a substantial effect in reducing CVD morbidity and mortality (Chiuve et al., 2006; Odegaard et al., 2011; Åkesson et al., 2014) independent of pharmacological treatment (Chiuve et al., 2006), thus serving as a promising target for interventions. Based on the social ecological model of health promotion (Golden et al., 2015; McLeroy et al., 1988), such interventions should adopt a population approach by targeting multiple levels of influence including the institution, the community and the built environment to create a

coherent and conducive setting for behavioral change. Therefore, while conventional interventions tend to focus on the knowledge, attitude and health literacy of individuals, researchers and policy makers are paying more attention to the influence of the environment.

Existing studies have examined the association between access to public amenities (such as public park (Bancroft et al., 2015; Sallis et al., 2016), public transportation (Sallis et al., 2016; Badland & Schofield, 2005), fast food restaurants (Reitzel et al., 2014) and primary care facilities (Wee et al., 2016)) and CVD risk factors (such as physical inactivity, obesity, unhealthy diet and lack of preventive health screening). However, most of them focused on the general population within the US or Europe as highlighted by recent systematic reviews (Papas et al., 2007; Ding & Gebel, 2012). This limits the generalizability of the findings to other settings and population subgroups such as individuals with lower socio-economic status (SES) who are known to have higher CVD risk (Clark et al., 2009) as well as poorer disease awareness, treatment and control (Wee & Koh, 2012). Besides fast food restaurants, there may also be other unhealthy food sources relevant in different cultural contexts. For instance, in Singapore, a multicultural island city state in South East Asia, hawker centers typically serve ready-to-eat street foods that contain more fat and fewer vegetables (Soon & Lam, 2008). They form an integral part of Singaporean's life and culture – almost half (49.3%) of adult Singaporeans dine at hawker centers six or more times per week due to busy lifestyle and affordable price (Soon & Lam, 2008; Health Promotion Board, 2004) – and are recognized as potential contributors to the rising rates of obesity in the country (Soon & Lam, 2008).

Our study examined the association between distance from residential housing to 5 health-promoting public amenities (public polyclinic, subsidized private clinic, healthier eatery, public park and train station) and 12 CVD risk factors (two variables on physical inactivity, five medical histories and five unhealthy dietary habits) among a low-income group living in subsidized rental flats in Singapore. The national median monthly household income of Singapore is $6000 (USD). Lower income individuals are defined as those with a monthly household income less than $1995 (USD) (Department of Statistics Singapore, 2016a) and are eligible to live in subsidized rental flats under the public housing scheme (Housing & Development Board Singapore, 2013). Our study addresses the evidence gap in urban low-income setting as well as local policy needs.

2. Methods

2.1. Hypotheses

Singapore has a total land area 719.7 sq.-km (approximately 65% the size of Hong Kong) with a population of 5 million. Primary care in Singapore is provided by public polyclinics and private general practitioners (GPs) (Khoo et al., 2014). Public polyclinics provide care at subsidized rates to all residents whereas within the private sector, the means-tested Community Health Assist Scheme (CHAS) scheme allows low and middle income Singaporean residents to receive subsidized medical and dental care from participating private GPs (CHAS clinics, hereafter addressed as "subsidized private clinics") (Ministry of Health Singapore, 2016). Despite their small numbers compared to their private counterparts (18 polyclinics vs > 2000 GP clinics), the polyclinics manage 55% chronic disease patients in the country (Khoo et al., 2014). Access to primary care has been associated with favorable behaviors such as higher uptake of cardiovascular screening (Wee et al., 2016) and preventive care (Starfield et al., 2005) which are important for the management of CVD. Therefore we hypothesized that living further away from these amenities would be associated with higher CVD risk.

Healthier eateries are canteens or restaurants endorsed and funded by the Singapore Health Promotion Board to provide beverages lower in sugar and food lower in calories, use healthier ingredients, serve more fruits and vegetables and incorporate less deep fried food in their menus (Health Promotion Board, 2015). Thus, we hypothesized that living further away from healthier eateries is associated with higher CVD risk, especially those related to unhealthy dietary habits.

The number of parks (Sallis et al., 2016) and access to public transport (Sallis et al., 2016) in a residential area have been associated with higher physical activities. Singapore has a well-connected train network (144 mass rail transit and light rail transit stations) with 2.5 million passenger trips a day, which approximate to 36% total public transport utilization in 2014). (Authority, 2015) Thus we also hypothesized that longer distance away to a park and to a train station were associated with an increase in CVD risk (Sallis et al., 2016).

2.2. Data sources

We obtained the spatial data (shapfiles) from the Singapore Land Authority (SLA) website (Singapore Land Authority, 2016) (subsidized private clinics, healthier eateries, public parks) or identified the locations of the amenities based on official addresses published on websites (train stations, public polyclinic, residential flats).

We obtained individual level data between 2013 and 2015 from the Singapore Heart Foundation Health Mapping Exercise (HME), a door-to-door annual health screening program for low income residents living in public rental flats in Singapore. (Singapore Heart Foundation, 2012) Public rental flats are publicly administered residential flats providing affordable housing for those with low income. In addition to demographic characteristics of individuals who responded to the invitation to health screening program, the data contained 12 CVD risk factors. Specifically, physical inactivity (two variables) included walking < 30 min every day last week and participated in sports < once a week; medical histories (five variables) included hypertension, diabetes, high cholesterol, heart attack and high BMI; unhealthy dietary habits (five variables) included consumption of fast food in the past one month, consumption of deep fried food, vegetables, fruits in the past one week and frequency of dining at hawker center in the past one week. Besides body mass index (BMI) which were measured by trained volunteers at screening, all variables were self-reported.

We obtained ethics approval from the National University of Singapore Institutional Review Board.

2.3. Inclusion & exclusion criteria

We limited our analysis to respondents ≥ 40 years old given their higher risk of CVD. To simplify the analyses, we considered the first participation to the health screening program. In addition, we removed a small number of respondents (n = 40, 1.7%) with > 2 year differences between reported and calculated age based on year of birth as a criteria for poor recall. The final analysis sample contained 1972 respondents.

2.4. Statistical analysis

We investigated the associations between the minimum distances from the residential housing of each respondent to the 5 public amenities (public polyclinic, subsidized private clinic, healthier eatery, public park and train station) and 12 CVD risk factors. As respondents clustered in residential blocks, we performed a series of logistic mixed effect regression models, specifying the residential blocks as the random effect. Each regression analysis used the minimum distance (in km) between residential housing and each public amenity as an independent continuous variable and a single risk factor as the dependent variable, controlling for demographic characteristics (gender, age group, housing type, marital and employment status).

For consistency, all risk factors were represented as binary variables such that the regressions are predicting higher risks or undesirable outcomes, notably walking < 30 min every day last week, participated in sports < once a week and less regular consumption of vegetables

(0–2 days in the past one week), less regular consumption of fruits (0–2 days in the past one week) and regular dining at hawker center (3–7 days in the past one week). We categorized respondents' age into four groups: 40–64; 65–74, 75–84, ≥ 85. Individuals ≥ 85 years old are considered the oldest old in literature (Campion, 1994; Dodge et al., 2008) and are beyond the life expectancy of Singaporeans (83 years old (Department of Statistics Singapore, 2016b)), therefore we did not divide the oldest age group further. We grouped BMI at screening into high or low based on World Health Organization's recommended cutoff for Asians (World Health Organization Expert Consultation, 2004), i.e. BMI ≥ 23. For all regressions, we reported results as odds ratios (OR) with 95% confidence intervals (95%CI).

To visualize the relationship between the different amenities and risk factors, we generated a heatmap based on the ratio of regression coefficient to its standard errors. To account for multiple comparisons, we used the false discovery rate (FDR, defined as the expected proportions of false positives among total number of positive associations (Benjamini & Hochberg, 1995)). This has been recommended for health studies as an alternative to the Bonferroni adjustment to avoid the problem of inflated Type II error rates (Glickman et al., 2014). Unlike *p*-value, there is no conventional threshold for FDR. We set our FDR threshold at 0.20 based on previous literature in epidemiology (Loftfield et al., 2015; Patel et al., 2010).

We used QGIS 2.10.1 for processing the spatial data and R 3.2.4 for data processing and analysis.

3. Results

3.1. Sample characteristics

Table 1 describes the characteristics of the 1972 respondents. Most respondents were females (52.8%) within working age group (40–64 years old, 47%). On average, they lived within 0.5 km of a subsidized private clinic (0.23 ± 0.13 km) and a healthier eatery (0.39 ± 0.21 m); within 1 km of the nearest train station (0.70 ± 0.34 km). The distance from their residential housing to the nearest park and the nearest polyclinic were 1.07 ± 0.61 m and 2.57 ± 2.59 km respectively.

3.2. Strength & direction of associations

Fig. 1 illustrates the associations between the distance from residential housing to public amenities and CVD risk factors from the regression analyses controlling for demographic characteristics without accounting for multiple comparisons. As all 5 amenities are suggested to be health-promoting (refer Methods), living further away from these amenities (indicating increasing geographical inaccessibility) should be positively associated with the CVD risk factors i.e. regression coefficient > 0.

In the heatmap, a darker shade of blue reflects stronger evidence toward positive association, which suggests that geographical inaccessibility to the amenity is a risk factor. Two examples were the association between distance to train station and low participation (< once a week) in sports (Less Sports) and the association between distance to park and consumption of vegetables for 0–2 days in the past one week (Less Vegetable).

In contrast, a white color indicates a highly significant negative association and suggests that geographical inaccessibility to the amenity is protective against the CVD risk factor instead. One example is the association between subsidized private clinics and a history of high cholesterol.

3.3. Associations with FDR < 0.20

Only two associations in Fig. 1 fell below the pre-specified FDR < 0.20 cutoff, summarized in Table 2. An additional 1 km distance from

Table 1
Characteristics of participants in Health Mapping Exercise 2013–2015.

Variable	N	(%)
Demographic characteristics		
Gender		
Male	931	47.2
Female	1041	52.8
Age group		
40–64	926	47.0
65–74	517	26.2
75–84	399	20.2
≥ 85	130	6.6
Marital status		
Married	467	23.7
Single	747	37.9
Separated/Divorced	258	13.1
Widowed	348	17.6
Employment status		
Yes	443	22.5
No	1443	73.2
Ethnic group		
Chinese	1208	61.3
Malay	553	28.0
Indian	183	9.3
Others	28	1.4
Housing type		
1-Room	1213	61.5
2-Room	747	37.9
Physical activities		
Walked < 30 min every day last week		
Yes	494	25.1
No	1422	72.1
Had sports < once a week		
Yes	1125	57.0
No	777	39.4
Dietary habits		
Ate deep fried food in the past one week		
Yes	1104	56.0
No	798	40.5
How often did you eat at hawker center in the past one week?		
3–7 Days	886	44.9
0–2 Days	1027	52.1
How often did you eat vegetables in the past one week?		
3–7 Days	1548	78.5
0–2 Days	377	19.2
Ate fast food in the past one month?		
Yes	339	20.2
No	1498	76.0
How often did you eat fruits in the past one week?		
3–7 Days	1252	63.5
0–2 Days	659	33.4
Medical histories		
Hypertension		
Yes	917	46.5
No	983	49.8
Diabetes		
Yes	466	23.6
No	1418	71.9
Heart attack		
Yes	169	8.6
No	1724	87.4
High cholesterol		
Yes	798	40.5
No	1055	53.5
Body mass index, kg/m^2		
≥ 23	955	48.4
< 23	898	45.5
Minimum distance to (Mean ± SD, km)		
Train station		0.70 ± 0.34
Healthier eatery		0.39 ± 0.21
Park		1.07 ± 0.61
Public polyclinic,		2.57 ± 2.59
Subsidized private clinic (CHAS clinic)		0.23 ± 0.13

Notes: Percentages may not add up to 100% due to missing data.
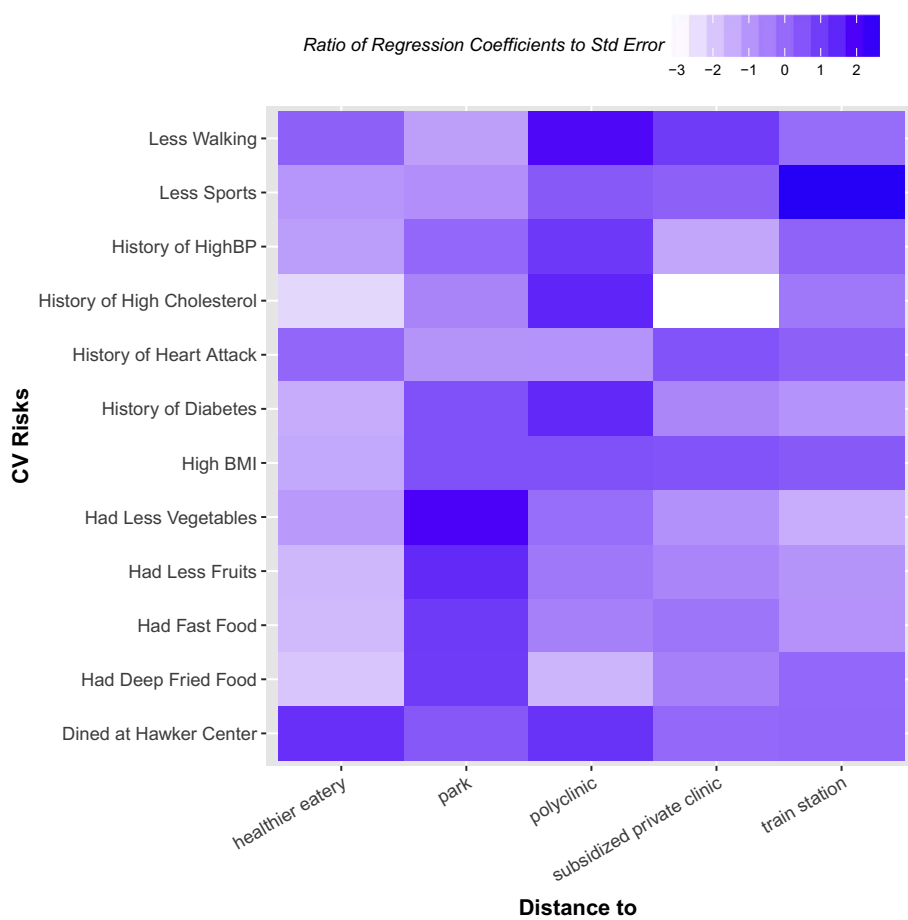Abbreviations: Community Health Assist Scheme (CHAS).

Fig. 1. The heatmap illustrates the associations between cardiovascular risk factors (y-axis) and distances to amenities (x-axis) among our study samples, after adjusting for demographic characteristics (gender, age group, housing type, marital and employment status). All CVD risk factors are binary. The heatmap presents the ratio of estimated coefficient to its standard error. Darker shade indicates higher odds of having a specific CVD risk factor as the distance to a specific amenity increases (suggesting inaccessibility to the amenity is a risk factor). In contrast, lighter shade indicates lower odds of having a specific CVD risk factor as the distance to a specific amenity increases (suggesting inaccessibility to the amenity is protective against the CVD risk factors). High BMI refers to BMI $> 23 \text{ kg/m}^2$. All risk factors were self-reported, except BMI which was measured by trained volunteers.

Table 2
Distance measures significantly associated with cardiovascular risk factors among participants in Health Mapping Exercise 2013–2015.

CVD risk	Amenities	Odds Ratio	95% CI	*p*-Value
Had sports less than once a week	Train station	1.73	1.18–2.55	0.006
History of high cholesterol	Subsidized private clinic	0.27	0.12–0.61	0.002

residential block to the nearest train station was associated with higher odds of not participating in sports (OR 1.73; 95% CI 1.18–2.55). In contrast, an additional 1 km distance from a subsidized private clinic was associated with lower odds of having a history of high cholesterol (OR 0.27; 95% CI 0.12 - 0.61). The direction of association and statistical significance for the two regressions remained even after respondents with self-reported stroke and heart attack from analyses were excluded. Interestingly, our analysis found no association between distances to the public amenities with unhealthy dietary habits such as fast food consumption.

4. Discussion

We used a systematic multiple outcome-exposure analysis approach to identify the association between distance to 5 health-promoting public amenities and 12 CVD risk factors among the population with low SES in the urban city state of Singapore. Accounting for multiple comparisons, our findings suggest that CVD risk factors among our study sample may be amenable by geographical access to health-promoting public amenities. This has implications in population health

strategies to mitigate CVD risk factors among the socio-economically disadvantaged population living in the city state. To the best of authors' knowledge, our study is also the first in the Asian Pacific region to explore the associations between distance to public amenities and CVD risk factors.

Our results imply that those living closer to subsidized private clinics may have benefited from the free health screening under the subsidy scheme, which included cholesterol testing (Health Promotion Board, 2014). This may explain the reduction in the odds of a diagnosis of high cholesterol with increasing distance from a subsidized private clinic. Meanwhile, the associations for the other three medical histories (diabetes, hypertension and heart attack) did not achieve statistical significance although the odds ratios were in the favorable direction. As these diseases are often symptomatic unlike high cholesterol, patients may have sought healthcare to address their symptoms regardless of their access to a subsidized private clinic.

Our analysis also suggests that living further from the nearest train station is associated with higher odds of not exercising regularly (at least once a week). There are two plausible explanations. Those who resided further from a train station may have poorer access to sports and recreation activities compared to those who lived closer. They would also need to walk further to access the public transport and hence have less need or time to be active in sports (Badland & Schofield, 2005). The latter may be the case for our study samples as 72.1% respondents reported walking ≥ 30 min every day. Further studies may be required to explore the underlying reasons given its potential impact on urban design and health promotion.

Interestingly out of the 60 hypotheses, only two (3.3%) achieved statistical significance after accounting for multiple comparisons. It was possible that individual factors such as age, gender and employment status played a stronger role than access to public amenities among our

socio-economically disadvantaged study samples. Several studies found that proximity to park was significantly associated with higher physical activities (Bancroft et al., 2015; Sallis et al., 2016). In our analyses, increasing distance (geographical inaccessibility) to park was positively associated with higher odds of less vegetable and fruits consumption, deep fried food and fast food consumption in the preceding week/ month, high BMI at screening and a history of diabetes, although our analyses did not achieve statistical significance (results in Supplementary Table 1). Proximity to park and availability of park facilities may not necessarily translate to park use or park-based physical activities and the effect may vary across different demographic groups (Kaczynski et al., 2014). Similarly, we also observed a non-significant positive association between increasing distance to healthier eatery and higher odds of dining at hawker center. In the US, policies to increase access to healthy grocery stores and supermarkets in poorer neighborhoods have been shown to merely improve awareness without a change in dietary habits (Cummins et al., 2014), suggesting that having access to healthy food source alone may not be sufficient to reduce CVD risk although we could not discount any potential benefits which may take longer to manifest.

5. Limitations

As participation in HME was voluntary, the respondents may not be fully representative of all individuals with low SES in Singapore. Most individual data were self-reported by the respondents and may be subjected to recall and social desirability bias. In addition, our cross sectional design cannot establish causality. Besides distance to the nearest of each amenity, density of the amenities within certain radius from residential housing is also an alternative proxy of access (Bancroft et al., 2015; Reitzel et al., 2014). Nevertheless, due to the lack of local literature to guide assumptions on the travel radius to access each amenity and the small land area of Singapore, we considered the distance to the nearest amenity as a more meaningful proxy of access.

The adjustment for multiple comparisons may have introduced type II errors i.e. erroneously rejecting true associations between distance and risk factor. While combining related risk factors e.g. unhealthy dietary habits into a score variable may reduce the number of hypotheses, it would require the use of locally validated scales e.g. structured food frequency questionnaire validated against 24-h dietary recall interviews (Hankin et al., 2001) and biomarkers (Seow et al., 1998), which was not supported by our data. Nevertheless, by examining specific CVD risk factors our analysis highlighted two associations that may merit further investigations which would otherwise be impossible if the risk factors were aggregated into a score.

Due to the lack of income and education level data, we adjusted the regressions for housing type and employment status as proxies of SES (Housing & Development Board Singapore, 2013) as our respondents must undergo means testing to be eligible for the subsidized public housing and would therefore fall under the same income bracket. Our results assumed the geographical distributions of the amenities were static throughout 2013 to 2015 which may also not be true. Lastly, we estimated straight line distances from residences to the amenities. Nonetheless, given the extensive road and public transport network in Singapore, they likely does not differ much from the actual road distances, especially for subsidized private clinics and healthier eateries located within 200 to 400 m from the residences. There is also evidence that straight line distance is a valid proxy for traveling distance and time (Bliss et al., 2012).

6. Conclusion

Our results provide insights into the relationship of distance from residence to several public amenities with CVD risk factors among a sample of lower income Singaporeans. In particular, geographical inaccessibility to the nearest train station was associated with less regular participation in sports and living further from subsidized private clinics was associated with lower odds of having diagnosed high cholesterol. While not establishing causality, our findings may warrant further investigations to better target health-promoting activities among individuals with lower SES.

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Conflict of interest

The study involved no funding. The authors declare that they have no conflict of interest.

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