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ORIGINAL RESEARCH

Are Measures Derived From Land Use and Transport Policies Associated With Walking for Transport?

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Background: There is growing urgency for higher quality evidence to inform policy. This study developed geographic information system spatial measures based on land use and transport policies currently used in selected Australian states to assess which, if any, of these measures were associated with walking for transport. **Methods:** Overall, 6901 participants from 570 neighborhoods in Brisbane, Australia, were included. Participants reported their minutes of walking for transport in the previous week. After a review of state-level land use and transport policies relevant to walking for transport across Australia, 7 geographic information system measures were developed and tested based on 9 relevant policies. Data were analyzed using multilevel multinomial logistic regression. **Results:** Greater levels of walking for transport were associated with more highly connected street networks, the presence of public transport stops, and having at least 2 public transport services per hour. Conversely, neighborhoods with shorter cul-de-sac lengths had lower levels of walking for transport. There was no evidence of associations between walking for transport and street block lengths less than 240 m or traffic volumes. **Conclusions:** These findings highlight the need for urban design and transport policies developed by governments to be assessed for their impact on transport-related physical activity.

Keywords: active transport, built environment, epidemiology, physical activity, policy, walkability

Living in more “walkable” environments encourages physical activity by providing opportunities to incorporate walking into daily activities,[1] which has potential to lower the prevalence of overweight and obesity.[2] However, rates of walking for transport in Australia are relatively low. For example, only 3.8% walked as their main form of transport to work or full-time study in 2012, along with 4.0% in 2009, and 4.2% in 2006.[3] A recent review by Wang et al[4] identified key built environment attributes within residential neighborhoods that facilitate higher levels of transportation walking, including higher residential density,[5] a mix of destinations accessible within 10 minutes,[6–8] improved street connectivity,[9] sun-protected areas,[10] public transport,[10] well-maintained footpaths,[10] and safety from traffic.[11]

Government policy shapes the physical makeup of communities and the distribution of services. It therefore plays a key role in creating neighborhoods that support walking for transport. However, there is an existing gap in the literature examining built environment measures that align with current neighborhood land use and transport policies.[12] This lack of evidence makes it difficult for policy makers to assess whether, and which, urban design principles are effective in encouraging more walking for transport. Creating spatial geographic information system (GIS) measures that are derived from policy are useful for monitoring the success (or otherwise) of current policy and inform the development of future neighborhood land use and transport policies that would help to deliver more walkable, liveable environments that promote transport walking.[13,14] This approach differs from most research to date, which derives spatial built environment measures from the literature[15] or environmental audits.[16] Our previous work has sought to identify the most useful transport spatial indicators that support or hinder health behaviors and outcomes and that policy makers and planners could apply to monitor and benchmark transport infrastructure.[14]

Developing GIS measures based on current policy could facilitate the replication or adaption of measures based on policies if found to facilitate walking for transport. This study identified spatial transport-related policies currently being used across selected Australian states and developed GIS exposure measures based on those policies. These were then used to examine which, if any, of these measures were associated with walking for transport.

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Methods

Data from the third wave of the How Areas in Brisbane Influence Health and Activity (HABITAT) project were used. Details about HABITAT and its sampling design have been published elsewhere.[17] Briefly, a multistage probability sampling design was used to select a stratified random sample (n = 200) of Census Collector’s Districts from the Australian Bureau of Statistics, and from within each Census Collector’s District, a random sample of people aged 40–65 years (n = 16,127). After excluding out-of-scope respondents (ie, deceased, no longer at the address, unable to participate for health-related reasons), the response rate at baseline was 68.4% (11,035 surveys from 16,127 eligible and contactable respondents in 2007), 72.4% in 2009 (7867/10,866), and 66.8% in 2011 (6901/10,327). The HABITAT study was approved by the human research ethics committee of the Queensland University of Technology, Brisbane, Australia (Ref. no. 3967H).

Identification of Spatially Relevant Transport Policies

In Australia, each state develops its own set of transport policies, and therefore policies often differ between states. In 2014, all current state-level transport-related land use and transport policies specifying area and distance attributes (ie, spatial) were identified for the Australian Capital Territory, New South Wales (NSW), Queensland (QLD), Victoria (VIC), and Western Australia (WA). Once the initial policies were identified (n = 78), the research team excluded spatially relevant transport policies that could not be operationalized with readily available data (n = 69), including the design of public transport stops, the availability of bicycle racks, and the provision of footpaths. The final list of spatial transport measures was reviewed for completeness by the National Liveability Study's Advisory Group, which consisted of state and federal policy makers, practitioners, and nongovernment organization representatives. Potential spatially bound measures were circulated electronically to the advisory group for comment, with a particular focus on appropriateness of the measures, and whether any additional measures needed to be considered. The Advisory Group responded with comments and adjustments as necessary. Five built environment measures based on Australian state-level land use and transport policies were identified within the broad area of neighborhood design: street connectivity (from NSW), cul-de-sac length (one from each of WA and NSW), street block length (from VIC), and traffic volume (from NSW), whereas 4 policies identified were related to public transport: the proximity of public transport stops (one from each of VIC, WA, and NSW) and public transport frequency (from NSW).

Creation of Spatial Measures

Spatial measures were developed at the individual level using network buffers with ArcGIS 10.2,[18] including the Network Analyst extension for routing and distance calculations and BetterBusBuffers[19] toolset for analyzing bus service frequency (Table 1). The spatial measures were created using readily accessible data from: Brisbane City Council, Department of Transport and Main Roads (Queensland), and Pitney Bowes Australia Pty Ltd. Street connectivity was measured using a Pedshed ratio, that is, the area of the 400 m road network service buffer divided by the area of 400 m radial buffer. The traffic volume measure was calculated based on a proxy measure of vehicles per day traversing each road segment based on the road hierarchy classification of road segments (measured in meters) using Equation (1), with a higher ratio indicating a

Table 1 State-Level Spatial Policy Measures, GIS Measures, and Modeling Approach

Quantitative spatial policy measure	GIS measure	Modeling
Neighborhood design		
Connectivity		
High proportion of potential 400 m walking catchment is walkable[20]	Pedshed ratio (area of 400 m network service area divided by area of 400 m radial buffer)	Divided into quintiles
Cul-de-sac length		
Maximum cul-de-sac length is ≤120 m[21]	Maximum cul-de-sac length (m) within 400 m service area	Dichotomized into >120 m vs ≤120 m
Maximum cul-de-sac length is ≤80 m[22]	Maximum cul-de-sac length (m) within 400 m service area	Dichotomized into >80 m vs ≤80 m
Street block length		
Street blocks 120–240 m long and 60–120 m wide[23]	Average block length (m) for 400 m service area	Dichotomized into >240 m vs ≤240 m
Traffic volume		
85% of households should be located on a road with a traffic volume <1500 vehicles per day[22]	Traffic volume within a 800 m radial buffer from residence	Divided into quintiles
Public transport		
Public transport stops		
400 m street walking distance around each existing or proposed bus stop[23]	Network distance (m) to nearest bus stop	Dichotomized into the presence of a stop within 400 m of the residence
≥60% of dwellings should be in a safe 400 m walk from a neighborhood or town center or an existing or potential bus stop[24]		
Every household should be within 400 m of a bus stop[25]		
Public transport frequency		
Every household should be within 400 m of a bus stop, with at least 1 service every 30 min[25]	Mean number of transit trips per stop that the nearest stop (within 1.6 km) between 7 AM and 7 PM on a weekday	Dichotomized into ≥2 services per hour vs <2 services per hour

Abbreviation: GIS, geographic information system.

Table 2 Correlations Between State-Level Spatially Relevant Transport Policy Measures[a]

	Connectivity	Cul-de-sac length 80 m	Cul-de-sac length 120 m	Street block length	Traffic volume	Public transport stops	Public transport service frequency
Connectivity	1.00						
Cul-de-sac length 80 m	0.32	1.00					
Cul-de-sac length 120 m	0.27	0.69	1.00				
Street block length	0.12	–0.04	0.04	1.00			
Traffic volume	–0.00	–0.00	0.06	0.03	1.00		
Public transport stops	0.40	0.22	0.21	0.15	0.17	1.00	
Public transport service frequency	–0.07	–0.09	–0.08	0.02	0.01	–0.10	1.00

[a]Correlations calculated using Kendall's tau-b.

higher traffic volume. The public transport frequency measure used the General Transit Feed Specification),[26] a widely adopted, standardized format for public transportation schedules and associated geographic information. Correlations between spatial measures were calculated using Kendall's tau-b in Stata[27] and ranged from –0.10 to 0.69 (Table 2).

$$\text{Traffic volume} = \frac{\sum(\text{Meters of highway, freeway, main road connector})}{\sum(\text{Meters of local and minor road})} \quad (1)$$

Outcome Measure

Walking for Transport. Participants responded to the item "What do you estimate was the total time spent walking for transport in the last week?" Corresponding text was included that described transport as "things like travel to and from work, to do errands, or to go from place to place," and participants were instructed not to include any walking for exercise or recreation. The walking for transport measure was highly positively skewed (skewness of 10.34) and did not meet the normality distribution assumption for linear regressions.[28] For analysis, walking for transport was therefore categorized into the following categories: none (0 min), low (1–59 min), moderate (60–149 min), and high (150 min+).

Covariates

Education. Participants were asked to provide information about their highest educational qualification attained. A participant's education was subsequently coded as (1) bachelor degree or higher (including postgraduate diploma, master's degree, or doctorate), (2) diploma (associate or undergraduate), (3) vocational (trade or business certificate or apprenticeship), and (4) no postsecondary school qualifications.

Occupation. Participants who were employed at the time of completing the survey were asked to indicate their job title and then to describe the main tasks or duties they performed. This information was subsequently coded to the Australian Standard Classification of Occupations (ASCO).[29] The original 9-level ASCO classification was recoded into 5 categories: (1) managers/professionals (managers and administrators, professionals, and paraprofessionals), (2) white collar employees (clerks, salespersons, and personal service workers), (3) blue collar employees (tradespersons, plant and machine operators and drivers, and laborers and related workers), (4) home duties, (5) retired, and (6) not easily classifiable (not employed, students, permanently unable to work, other, and missing).

Household Income. Participants were asked to estimate their total pretax annual household income using a single question comprising 13 income categories. For analysis, these were recoded into 6 categories: (1) ≥AU$130,000, (2) AU$129,999–AU$72,800, (3) AU$72,799–AU$52,000, (4) AU$51,999–AU$26,000, (5) ≤AU$25,999, and (6) not classified (ie, left the income question blank, ticked "don't know" or "don't want to answer this").

Neighborhood Disadvantage. Neighborhood socioeconomic disadvantage was derived using scores from the Australian Bureau of Statistics Index of Relative Socioeconomic Disadvantage.[30] A neighborhood's Index of Relative Socioeconomic Disadvantage score reflects each area's overall level of disadvantage measured on the basis of 17 variables that capture a wide range of socioeconomic attributes, including education, occupation, income, unemployment, household structure, and household tenure. The socioeconomic scores for each HABITAT neighborhood were then quantized as percentiles relative to all of Brisbane. The 570 HABITAT neighborhoods were then grouped into quintiles with Q1 denoting the 20% most disadvantaged areas relative to the whole of Brisbane and Q5 the least disadvantaged 20%.

Other Potential Confounders. Participants were asked to report their gender and date of birth, which was subsequently converted to years of age.

Statistical Analysis

Participants who had missing data for walking for transport and education were excluded (n = 654), which reduced the final sample to n = 6247 (90.5% of the total sample). The analysis was informed by postulated relationships between neighborhood transport infrastructure and walking for transport, adjusted for potential confounders: age, sex, neighborhood disadvantage, education, occupation, and household income. These relationships are depicted in a directed acyclic graph (Figure 1). Multilevel multinomial logistic regression was used, with walking for transport as the dependent variable (0 = none—reference category, 1 = low, 2 = moderate, and 3 = high), and built environment measures were included as the independent variables in separate models. Each regression used marginal quasi-likelihood iterative generalized least squares methods as the base estimates for Markov chain Monte Carlo estimation (burn-in = 500, chain = 50,000). All results

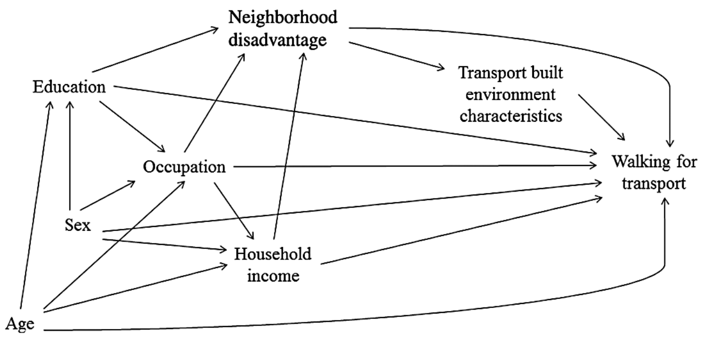

Figure 1 — Directed acyclic graph conceptualizing the relationships between neighborhood disadvantage, transport built environment characteristics, individual-level socioeconomic characteristics, and walking for transport.

are reported as odds ratios and their 95% credible intervals. Data were prepared in Stata SE version 13,[27] and all analyses were completed in MLwIN version 2.32.[31]

Results

Descriptive statistics for the spatial measures and walking for transport are presented in Table 3; and the socioeconomic measures (covariates) and walking for transport are presented in Table 4. The majority of participants (61.4%) did not engage in any transport walking during the previous week, while 17.4% engaged in moderate, 14.7% low, and 6.5% high walking.

Associations between spatial measures and walking for transport are presented in Table 5. Participants with more highly connected streets around their residence had greater odds of being in the low, moderate, and high categories of walking for transport. Participants with public transport stops within 400 m of their residence had greater odds of being in the low category of walking for transport, but there was no association with higher levels of walking. Participants with a more frequent public transport service (ie, at least 2 public transport services per hour) had greater odds of walking for transport for 150 minutes per week or greater.

Participants with cul-de-sac lengths ≤80 m or ≤120 m around their residence had lower odds of being in the low category of walking for transport (ie, were more likely to undertake no walking for transport); whereas cul-de-sac length was not significantly associated with higher levels of walking. There was no evidence of associations between walking for transport and smaller street block length or lower levels of local traffic.

Discussion

This study developed GIS measures based on spatially relevant transport and land use policies currently being used across selected Australian states and examined associations with walking for transport. With some exceptions, we found mixed evidence that GIS spatial measures based on current urban and transport policies were associated with walking for transport. Our investigation revealed that participants were more likely to walk for transport if they lived in neighborhoods with more connected street networks —but not living in neighborhoods with shorter cul-de-sac length. These findings reinforce the importance of building neighborhoods with highly connected street networks as the basic building block of a liveable neighborhood.[32] At least in Brisbane, these types of policies are likely to be more important than policies that limit cul-de-sac length. Similarly, although proximity to public transport stops is important for transport walking, higher levels of walking appeared more likely only in areas where there were more frequent public transport services. Our study did not find any associations with street block length and walking for transport, which is consistent with Oakes et al,[33] although inconsistent with findings in Perth, Australia.[32] Once again, areas with highly connected street networks are also more likely to have shorter block lengths, and perhaps focusing policies on the former, rather than the latter, may be more important.

A recent review of the literature found that the real and perceived danger and discomfort imposed by traffic discouraged walking.[34] However, we found no evidence that living in areas with lower traffic volume encourages more walking for transport in adults. This finding is not surprising. Areas with more shops and services not only encourage more walking but also attract more motor vehicle traffic as both pedestrians and motorists access those shops and services. In previous research, we found a negative interaction between street connectivity and traffic volumes, whereby primary school aged children whose school was located in areas with highly connected street networks, but high levels of traffic were less likely to walk.[35] However, in able-bodied adults, neighborhoods with more shops and services encourage walking even in the presence of traffic, although plausibly there may be an optimum level of traffic beyond which traffic declines. Future studies may wish to explore varying our traffic exposure measure from a focus on low levels of traffic, as required for active transport in primary school aged children, to explore an optimum level of traffic that creates vibrant yet pedestrian-friendly neighborhoods.

The literature in this field is somewhat inconsistent, likely due to differences in the development of objective built environment measures and the scale at which they are applied. The focus of this paper was whether GIS measures based on relevant contemporary land use and transport policies were associated with transport walking, an approach which is increasingly being called for in the literature.[12] Hence, comparing these findings with earlier studies is problematic because the majority of the measures used in this study were based on government policies rather than previous literature. Nevertheless, Turrell et al[15] (using the baseline wave of the HABITAT study) found that the amount of walking for transport increased with the number of neighborhood 4-way intersections, though in the US, Forsyth et al[36] did not find any associations with walking and measured intersection density. Rajamani et al[37] found that percentage of culs-de-sac in the neighborhood was negatively associated with transport walking, whereas our study found negative associations between the presence of a shorter cul-de-sac network (ie, the maximum cul-de-sac length within the 400 m service area was within the maximum recommended by the policy) and levels of walking for transport.

The absence of data on the pedestrian network (ie, footpaths and cut throughs at the end of cul-de-sacs) meant that any pedestrian paths at the end of culs-de-sac were undetected. A Western Australian study[38] found that neglecting pedestrian cut throughs at the end of cul-de-sacs underestimated the walkability of neighborhoods. It is possible that the less-connected streets with pedestrian cut throughs at the end of cul-de-sacs may enhance transport walking conditions due to less through traffic, which is consistent with this study's findings.

Associations between transport walking and the presence of public transport stops are mixed, with Cerin et al[5] finding no associations, unlike others.[10] However, in this study, we found that

Table 3 Frequencies of Walking for Transport by Spatial Transport Measures: Persons Aged 40–65 Years in the HABITAT Analytic Sample (n = 6247)[a]

	Walking for transport									
	None (0 min)		Low (1–59 min)		Moderate (60–149 min)		High (>150 min)		Total	
	N	%	N	%	N	%	N	%	N	%
Neighborhood design										
Connectivity										
Q5 (lowest)	842	67.9[b]	150	12.1[b]	188	15.2	60	4.8[b]	1240	19.9
Q4	799	63.8	175	14.0	207	16.5	72	5.8	1253	20.1
Q3	772	61.9	171	13.7	223	17.9	82	6.6	1248	20.0
Q2	720	57.7	198	15.9	223	17.9	106	8.5[b]	1247	20.0
Q1 (highest)	705	56.0[b]	225	17.9[b]	245	19.5	84	6.7	1259	20.2
P-value					<.001					
Cul-de-sac length										
80 m										
>80 m	1791	61.1	458	15.6	501	17.1	181	6.2	2931	46.9
≤80 m	2047	61.7[b]	461	13.9[b]	585	17.6	223	6.7[b]	3316	53.1
P-value					<.001					
120 m										
>120 m	1052	61.0[b]	286	16.6	185	16.5	101	5.9[b]	1724	27.6
≤120 m	2786	61.6[b]	633	14.0	801	17.7	303	6.7[b]	4523	72.4
P-value					<.001					
Street block length										
>240 m	429	64.4	87	13.1	102	15.3	48	7.2	666	10.7
≤240 m	3409	61.1	832	17.9	984	17.6	356	6.4	5581	89.3
P-value					.178					
Traffic volume										
Q5 (highest)	756	60.7	184	14.8	227	18.2	79	6.3[b]	1230	19.7
Q4	748	59.7	187	14.9	224	17.9	93	7.4	1252	20.0
Q3	239	58.3	209	16.5	224	17.7	95	7.5	1267	20.3
Q2	792	63.3	179	14.3	206	16.5	75	6.0	1252	20.0
Q1 (lowest)	803	65.3	160	13.0	205	16.7	62	5.0	1246	20.0
P-value					.042					
Public transport										
Stops										
No stop within 400 m	1276	66.3[b]	229	11.9[b]	308	16.0	112	5.8	1925	30.8
Stop within 400 m	2562	59.3	690	16.0[b]	778	18.0	292	6.8	4322	69.2
P-value					<.001					
Service frequency										
<2 services per hour	1988	62.7	454	14.3	538	17.0	191	6.0	3171	50.8
≥2 services per hour	1850	60.1	465	15.1	548	17.8	213	6.9	3076	49.2
P-value					.176					
Total	3838	61.4	919	14.7	1086	17.4	404	6.5	6247	100.0

Abbreviation: HABITAT, How Areas in Brisbane Influence Health and Activity.
[a]Includes measures of association using Pearson's chi-squared.
[b]Indicates that Pearson's chi-squared standardized residuals fall beyond 1.96 SDs from the mean.

while the presence of public transport stops encourages more walking, the frequency of service is perhaps even more important. While we were unable to find comparative studies linking public transport service frequency with transport walking, evidence suggests that the frequency of a public transport service is an important predictor of its use.[39,40] Thus, it is reasonable to suggest that a minimum service frequency (eg, at least every 30 min or less as recommended by the policy) is required to encourage commuters to use public transport from which they would derive a walking trip.

Our study raises a number of questions in terms of land use and transport policies. We examined associations between walking for transport and spatial measures derived from state-level transport

Table 4 Frequencies of Walking for Transport by Individual-Level Socioeconomic Characteristics and Neighborhood Disadvantage: Persons Aged 40–65 Years in the HABITAT Analytic Sample (n = 6247)[a]

	Walking for transport									
	None		Low		Moderate		High		Total	
	N	%	N	%	N	%	N	%	N	%
Age, y										
40–44	101	47.0[b]	42	19.5	52	24.2[b]	20	9.3	215	3.4
45–49	783	58.2	199	14.8	261	19.4	103	7.7	1346	21.6
50–54	739	57.2	184	14.2	271	21.0[b]	98	7.6	1292	20.7
55–59	847	64.5	163	12.4[b]	213	16.2	91	6.9	1314	21.0
60–64	937	65.4	216	15.1	208	14.5[b]	71	5.0[b]	1432	22.9
65–70	431	66.5	115	17.8[b]	81	12.5[b]	21	3.2[b]	648	10.4
P-value					<.001					
Sex										
Male	1601	59.3	397	14.7	499	18.5	205	7.6	2702	43.3[b]
Female	2237	63.1	522	14.7	587	16.6	199	5.6	3545	56.8[b]
P-value					.001					
Education										
Bachelor+	1124	52.7[b]	378	17.7[b]	461	21.6[b]	172	8.1[b]	2135	34.2
Diploma/Assoc. deg	436	59.8	130	17.8[b]	122	16.7	41	5.6	729	11.7
Certificate (trade/business)	708	66.0	122	11.4[b]	172	16.0	71	6.6	1073	17.2
None beyond school	1570	68.0[b]	289	12.5[b]	331	14.3[b]	120	5.2[b]	2310	37.0
P-value					<.001					
Occupation										
Mgr/prof	1186	56.0[b]	321	15.2	438	20.7[b]	174	8.2[b]	2119	33.9
White collar	751	61.4	162	13.3	244	20.0[b]	66	5.4	1223	19.6
Blue collar	504	69.9[b]	69	9.6[b]	95	13.2[b]	56	7.4	721	11.5
Home duties	250	73.8[b]	40	11.8	35	10.3[b]	14	4.1	339	5.4
Retired	733	66.3[b]	199	18.0[b]	139	12.6[b]	35	3.2[b]	1106	17.7
Not easily classifiable	414	56.0	128	17.3	135	18.3	62	8.4[b]	739	11.8
P-value					<.001					
Household income										
$130,000+	747	56.1[b]	206	15.5	279	21.0[b]	99	7.4[b]	1331	21.3
$72,800–$129,999	913	60.0	206	13.5	293	19.3	109	7.2	1521	24.4
$52,000–$72,799	487	62.5	124	15.9	128	16.4	40	5.1	779	12.5
$26,000–$51,599	712	65.1	154	14.1	165	15.1	62	5.7	1093	17.5
Less than $25,999	360	60.5	106	17.8[b]	90	15.1	39	6.6	595	9.5
Not classified	619	66.7[b]	123	13.3	131	14.1	55	5.9[b]	928	14.9
P-value					<.001					
Neighborhood disadvantage										
Q1 (least disadvantaged)	913	62.8	231	15.9	225	15.5	85	5.9	1454	23.3
Q2	1019	62.6	234	14.4	285	17.5	89	5.5	1627	26.0
Q3	743	59.3	192	15.3	227	18.1	92	7.3	1254	20.1
Q4	632	59.4	141	13.3	206	19.4	85	8.0	1064	17.0
Q5 (most disadvantaged)	531	62.6	121	14.3	143	16.9	53	6.3	848	13.6
P-value					.053					
Total	3838	61.4	919	14.7	1086	17.4	404	6.5	6247	100.0

Abbreviation: HABITAT, How Areas in Brisbane Influence Health and Activity.
[a]Includes measures of association using Pearson's chi-squared.
[b]Indicates that Pearson's chi-squared standardized residuals fall beyond 1.96 SDs from the mean.

Table 5 ORs (95% CrI) for Participants in Each Walking for Transport Category by Transport Spatial Measures

	Walking for transport[a]						
		Low		Moderate		High	
	None (reference group)	OR	95% CrI	OR	95% CrI	OR	95% CrI
Neighborhood design							
Connectivity[b]							
Q5 (lowest; 0.00–0.17)	1.00	1.00		1.00		1.00	
Q4 (0.17–0.26)	1.00	1.27	0.99–1.63	1.15	0.91–1.45	1.24	0.85–1.82
Q3 (0.26–0.33)	1.00	1.26	0.98–1.64	1.22	0.96–1.56	1.36	0.94–1.99
Q2 (0.33–0.41)	1.00	1.53	1.18–1.98	1.27	1.00–1.61	1.84	1.29–2.63
Q1 (highest; 0.41–1.00)	1.00	1.76	1.37–2.28	1.40	1.10–1.78	1.44	0.99–2.12
Cul-de-sac length							
80 m							
>80 m	1.00	1.00		1.00		1.00	
<80 m	1.00	0.83	0.71–0.97	0.98	0.84–1.14	1.02	0.82–1.28
120 m							
>120 m	1.00	1.00		1.00		1.00	
<120 m	1.00	0.77	0.65–0.92	1.01	0.85–1.20	1.07	0.83–1.41
Street block length							
>240 m	1.00	1.00		1.00		1.00	
<240 m	1.00.	1.22	0.95–1.58	1.18	0.93–1.50	0.92	0.66–1.33
Traffic volume[c]							
Q5 (highest; 0.40–4.51)	1.00	1.00		1.00		1.00	
Q4 (0.28–0.40)	1.00	1.05	0.82–1.34	1.01	0.80–1.29	1.2	0.85–1.69
Q3 (0.18–0.27)	1.00	1.16	0.91–1.48	0.99	0.78–1.27	1.28	0.90–1.83
Q2 (0.10–0.18)	1.00	0.92	0.72–1.19	0.87	0.68–1.11	0.96	0.65–1.40
Q1 (lowest; 0.00–0.10)	1.00	0.89	0.68–1.16	0.96	0.74–1.24	0.89	0.59–1.34
Public transport							
Stops							
>400 m	1.00	1.00		1.00		1.00	
<400 m	1.00	1.44	1.21–1.72	1.14	0.97–1.35	1.16	0.89–1.49
Service frequency							
<2 services per hour	1.00	1.00		1.00		1.00	
>2 services per hour	1.00	1.13	0.96–1.33	1.15	0.98–1.35	1.26	1.00–1.60

Abbreviations: CrI, credible intervals; OR, odds ratio.
[a]Models adjusted for age, sex, education, occupation, household income, and neighborhood disadvantage.
[b]Pedshed ratio at 400 m buffer.
[c]$\sum$(highway, motorway or freeway, main road, connector road)/$\sum$(local road and minor road).

and land use policies. We found mixed results, suggesting that some policies (eg, street connectivity) may be more important than others (eg, traffic volume). Our results highlight the need for urban design and transport guidance developed by governments to be assessed for their impact on walking for transport. Further, research is needed to assess measures based on policies in a variety of jurisdictions, to assess their potential to influence transport walking. This is increasingly important given the recent UN Sustainable Development goals[41] and increasing recognition of the need to create safe, resilient, and more sustainable cities. Evidence-based policy is required to ensure that policies intended to facilitate transport walking achieve their intent. This type of evidence will inform the development of new policies and the refinement and recalibration of existing policies.

There are several factors that may limit the generalizability of this study's findings. First, survey nonresponse in the HABITAT baseline study was 31.5% and slightly higher among persons of lower socioeconomic position and residents of more disadvantaged neighborhoods. However, lower response rates from individuals of lower socioeconomic backgrounds are common in epidemiological studies.[42] Second, the cross-sectional nature of the study design means that claims about causality must be made cautiously. Reverse causation is unlikely, as it seems improbable that the amount of transport walking undertaken by residents might determine the neighborhood transport infrastructure; however, it is possible that residents who were already transport walkers self-selected into neighborhoods with infrastructure that supports more walking for transport. Third, we used a self-reported measure of transport walking, which may be subject to recall bias.[43] It was noteworthy that the majority of the sample (61.4%) did not report any walking for transport, in what would seem an unlikely scenario given that even those that commute predominately by private motor vehicle would still undertake some form of transport walking (eg, within a parking lot). Fourth, we decided to omit transport policies that could not be assessed spatially or for which data were not available. This meant that only a small portion of transport policies identified in our review were analyzed in this study. Further, the spatial measures in this study were designed to match the Australian state-level transport policies as closely as possible given the limitations of available data and the detail described in the policy itself. Dividing the spatial measures into dichotomous categories simplifies the relationship between the spatial measures and the transport walking. Identifying the thresholds at which spatial measures have the most influence on access to transport infrastructure will provide further evidence for effective transport policy. Last, this study only considered the associations between transport policies and walking for transport. Future studies should be expanded to examine associations between transport policies and cycling to further assess their potential impact on physical activity.

This study found evidence of associations between policy-derived measures of the transport built environment and walking for transport. It is noteworthy that in our review of transport policies, of the 78 policies that were identified as being relevant to transport, only 9 could be assessed spatially. While this was partially because the spatial data were unavailable for the measure to be created (eg, provision of footpaths), it was often also due to the vague (or inexplicit) wording of policies (eg, principal cycle network not more than 1 km apart). To assess evidence-informed policy making, there is a need for policies to be articulated in ways that can be operationalized and tested. This would not only assist in evaluating their effectiveness for promoting walking for transport but would also help planners to implement policies effectively. This study highlights the importance of evidence-informed policy making to ensure that current policies achieve their intended outcomes.

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