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Transport Disadvantage, Social Exclusion and Subjective Wellbeing: The Role of Built Environment - Evidence from Sydney, Australia

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Abstract

This study explores the effects of the built environment on transport disadvantage, social exclusion, personal health and SWB using survey data collected in four socio-disadvantaged neighbourhoods in Sydney, Australia. The data is analysed at both neighbourhood and individual levels using both descriptive analysis and structural equation modelling (SEM). Overall, our model supports the hypothesis that a walkable neighbourhood environment, measured by density, diversity, access, and infrastructure for walking and cycling, helps to reduce transport disadvantage and increase social inclusion. However, the impact of the physical environment does not carry forward to impact personal health and SWB. The exception to this finding is where the environment is perceived to be aesthetically pleasing – a variable which significantly positively affects SWB. In addition to the physical environment, crime is a significant factor that directly influences transport disadvantage and SWB.

1. Introduction

The links between transport disadvantage, social exclusion and poor health and wellbeing outcomes are well established (Church et al., 2000; Currie et al., 2009; Currie and Stanley, 2007; Delbosc and Currie, 2011a; Lucas, 2012; Stanley et al., 2011). Good transport facilitates access, which enables participation in the activities that are important in life (Lucas, 2012). These activities include gainful employment, education and social and familial interactions (Ettema et al., 2010), as well as practices of self-care such as routine physical activity and healthy eating (Thompson and Kent, 2014).

While transport disadvantage features regularly in research, it remains a concept that is notoriously difficult to define and measure. These difficulties emanate from the fact poor access results from complex interactions of built, locational, socio-economic and demographic variables. This complexity is evident in many cities around the world, including those in Australia, which have 'grown up' post the industrial revolution, and in the era of private car emergence. This history has ensured a structure that has potential to both augment and complicate experiences of transport disadvantage. For example, the housing price gradient in these cities generally follows that of residential density, sloping from high to low as distance from the core to periphery increases. Low income populations are therefore often left with little choice but to live in outer suburban areas. The concentration of employment and service and recreational opportunities at the core subsequently forces these populations to travel long distances, and the lack of public transport options ensures that covering these distances is both difficult and expensive. Furthermore, distance and a paucity of infrastructural provision limits walking and cycling for transport, as well as other alternatives to private car ownership such as car sharing (Daniels and Mulley, 2012). In short, these lower income households are forced into the expense of private car ownership, requiring an allocation of relatively more income to cover the costs of transport necessary for social inclusion, and the maintenance of a reasonable standard of individual wellbeing.

2. Background

Previous studies linking transport disadvantage with social exclusion and poor well-being have explored the complexity described above, focusing primarily on the role of accessibility to different transport modes. Private car ownership and access to reliable public transport are often suggested as precursors to viable employment and participation in other activities and interactions, with this relationship particularly clear in research from low density Australian and North American contexts. For example, using data on welfare recipients in Alameda County, California, Cervero et al. (2002) found that car ownership was a significant predictor of transition to employment, while public-transport service quality variables were largely insignificant. Grengs (2010) also found that policies to facilitate private car use were most effective in improving employment opportunities for lower income residents in Detroit. Ong and Miller (2005) compared the impacts of spatial mismatch (the geographic separation of workers and jobs) and lack of access to a private automobile on neighbourhood unemployment rates in metropolitan Los Angeles. They found that lack of private vehicle access was relatively more important as a determinant of poor labour-market outcomes, particularly in low income neighbourhoods. Similar findings have been reported in Australia. Currie et al. (2009) assessed transport disadvantage and social exclusion on the urban fringe in Melbourne, Australia. They identified two types of transport disadvantaged groups – those who are forced to own a car and those without a car. They found that households forced to own cars are primarily those on low incomes. These households were found to be highly car dependent, lack alternative transport options, face high transport costs relative to income, and make less trips than the average car owning household in the same city.

Despite the focus on links between city structure and transport disadvantage evident in the studies reviewed above, little research has systematically investigated the role of more micro-characteristics of the built environment (such as street design and diversity of destinations) in shaping elements of transport disadvantage, social exclusion and wellbeing. Those that have generally concentrate on interactions at the aggregate geographic scale (for example, Delbosc and Currie (2011b) and Hurni (2007)). We propose that to really understand potential links between the built environment, transport disadvantage and wellbeing, research must be undertaken from the bottom up, starting with individual responses. This study fills this research gap.

This study aims to explore the potential effects of the built environment on transport disadvantage, social exclusion and wellbeing at the individual level. The purpose is to identify built environment indicators that can inform policies addressing transport disadvantage and social exclusion in low-income populations. This research also aims to contribute to existing theories of links between transport disadvantage, social exclusion, wellbeing and health, through a more robust consideration of the impact of the built environment on these links.

The built environment potentially influences transport disadvantage, social exclusion and wellbeing both directly and indirectly. First, travel characteristics, such as travel mode choice and travel cost, are endogenous to the built environment (Boarnet and Sarmiento, 1998). Research consistently demonstrates a link between transport practices and built environment characteristics, such as including residential density, land-use diversity, and pedestrian-friendly design. Increased diversity, for example, provides opportunities for the divestment of service and employment uses away from the city core, with subsequent impacts on distance, travel time and the viability of modes such transit, walking and cycling in suburban areas. This provides the residential populations of these areas, including lower income groups, with the opportunity to avoid the expense of private car ownership and potentially moderates exposure to transport disadvantage. Second, the built environment can also more immediately influence health and wellbeing, quite outside of its influence on transport and access opportunities. Numerous studies have concluded that people living in walkable, mixed-use neighbourhoods have higher wellbeing through greater connection to community, better access to healthy food, and opportunities for recreational and incidental physical activity, as compared to those living in homogenous areas designed to be navigated by car rather than on foot (Frank and Engelke, 2001; Kent and Thompson, 2014).

To inform our theoretical and empirical explorations, we have developed a framework to link the built environment, travel characteristics, social exclusion and subjective wellbeing (SWB). This framework is illustrated in Figure 1.

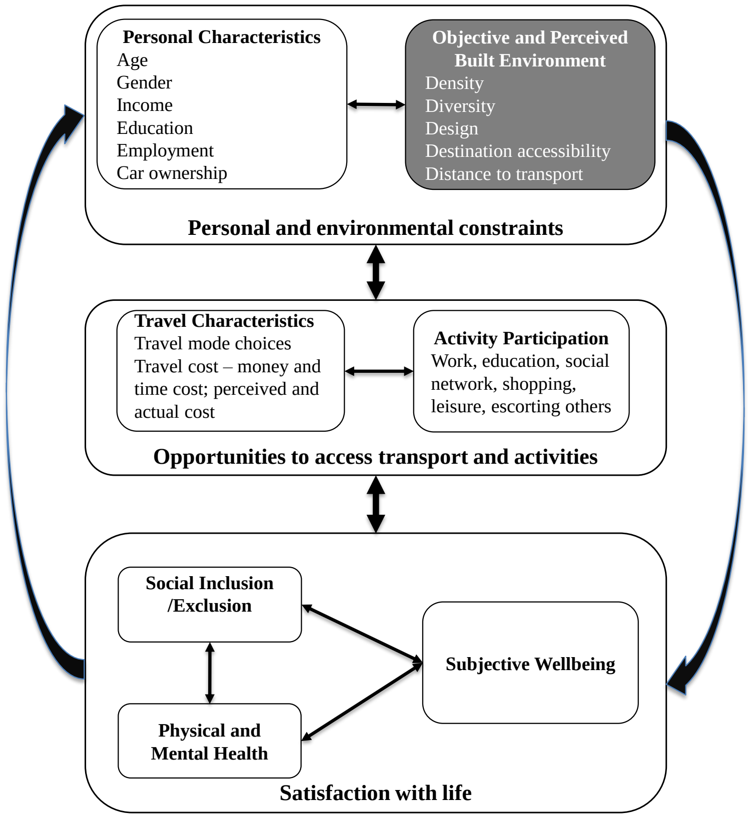

Figure 1 Links between the built environment, transportation, and subjective wellbeing

3. Method

3.1 Data and variables

Our primary method of data collection was a self-administered 13-page survey, mailed in April 2016 to households in four neighbourhoods [1] in Sydney, Australia. The four neighbourhoods were purposefully selected. We first created a list of all neighbourhoods in the Sydney Greater Metropolitan Area with a Socio-Economic Indexes for Areas (SEIFA) score within the lowest 7% of the state. Each neighbourhood was then categorised as having one of the following typologies: car-dependent, good access to public transport but not walkable, walkable but poor access to public transport, and walkable with good access to public transport. This categorisation was informed by measures of street layout, accessibility to business establishments and accessibility to public transport. We used Google maps, 'Walk score' and the PTAL score (public transport accessibility level score) (Transport for London, 2010) for this categorisation.

[1] The term 'neighbourhood' is used in this paper to refer to the medium sized general purpose area known as Statistical Area Level 2 (SA2) in the Australian Statistical Geographical Standard. An SA2 will generally cover a population between 10,000 and 25,000 and reflect a community that interacts together socially and economically. It can be located both within an urban metropolitan area or external to metropolitan boundaries. All 4 neighbourhoods selected for inclusion in this study are contained within the Sydney Greater Metropolitan Region.

One neighbourhood from each of the four typologies was then selected based on accessibility for the research team and a desire to examine an array of local government areas. The neighbourhoods selected were: Lansvale (car-dependent), Canterbury (good access to public transport and somewhat walkable), Hillsdale (very walkable but poor access to public transport), and Harris Park (very walkable and good access to public transport). Basic characteristics of each neighbourhood are presented in Table 1 with their spatial layout in Figure 2.

Table 1 Characteristics of the four neighbourhoods

	Harris Park	Hillsdale	Canterbury	Lansvale
Area (km^2)	0.64	0.55	1.99	2.89
SEIFA	941	942	981	921
Population	5072	4977	6159	2429
# bus stops	16	4	37	34
# train stations	3	0	3	0
Population density	7956	9110	3088	840
Street Connectivity (NodesRatio) [1]	0.94	0.82	0.85	0.75
WalkScore	83	81	71	51
PTAL[2]	23	17	21	7

[1] Nodes ratio is calculated based on: # intersections with 3+ valences **/** (# intersections with 3+ valences **+** # cul-de-sacs).
[2] The PTAL methodology defines accessibility in terms of the time taken to walk to a public transport access point (i.e. bus stop or railway station), the average waiting time for a public transport service at that access point and the reliability of the mode. A value of 0-10 indicates a very poor-poor service, a value of 10-15 indicates a moderate service, a value of 15-20 indicated a good service, a value of 20-25 indicates a very good service, and a value above 25 indicates an excellent service.

Figure 2 Spatial layout of the four neighbourhoods
Source: Google Image

1,600 household addresses, including resident names, were purchased from a list company, with 400 for each neighbourhood. We had hoped that a personally addressed survey would result in a more favourable response rate. A survey package consisting of the survey, a participant information statement, and a reply paid envelope was delivered by post to each of the addresses. The survey also contained details of an online option for survey completion. Each household returning a completed survey was offered the option to enter a draw to win one of ten $50 gift cards. The survey was mailed on March 31st, 2016 and would have arrived at the target households by April 4th, 2016, giving two weeks before the required return date. A reminder letter was sent to all addresses after a week, again in an effort to increase the response rate. The survey itself, and the process of participant recruitment, was granted approval by the ethics committee of the authors' institution.

The number of responses totalled 119, including 106 paper-based responses and 13 web-based responses. This is equivalent to an 8% response rate based on valid names and addresses only (119 out of 1,600 addresses were returned as not valid). Considering the length of the survey (20-25 minutes), and special characteristics of the target neighbourhoods (socially disadvantaged neighbourhoods), this response rate is respectable. The distribution of the responses is: 45 from Lansvale, 40 from Canterbury, 20 from Hillsdale, and 14 from Harris Park. Table 2 provides the sample characteristics. The sample is clearly not representative, given its small size. The respondents were more likely to be male (75% versus 52% from the 2011 Australian census and older (median age of 62 versus median age of 35 from 2011 Australian census). These variations are not expected to materially affect the analysis and results given the focus of this study is to explore the relationships between various factors. They do, however, limit the generalisation of the results of this study to a wider population.

Table 2 Characteristics of respondents

	N	Minimum	Maximum	Mean	Std. Deviation
Female	117	0	1	25%	0.4
Age	111	21	97	61.0	14.5
# vehicles	114	0	6	1.7	1.1
Education[1]	112	1	8	5.7	1.5
HH income[2]	93	1	12	6.6	2.5
Hold drivers' license	114	0	1	89%	0.3
Employed	113	0	1	46%	0.5

[1] 1-Did not go to school; 2-Some primary school; 3-Some secondary school; 4-Finished primary school; 5- Finished secondary school; 6- Completed post-school certificate or diploma; 7-Completed bachelor degree qualification; 8-Completed post-graduate qualification.
[2] 1: Negative or Zero Income; 2: $1-$189 per week; 3: $190 - $379 per week; 4: $380 - $579 per week; 5: $580 - $769 per week; 6: $770 - $959 per week; 7: $960 - $1149 per week; 8: $1150 - $1529 per week; 9: $1530 - $1919 per week; 10: $1920 - $2399 per week; 11: $2400 - $2879 per week; 12: $2880 - $3839 per week; 13: $3840 or more per week.

The variables used in this study consist of five groups: neighbourhood environment, transport disadvantage, social exclusion, physical and mental health, SWB, and demographics. The measurements of these variables are described below.

Neighbourhood environment

Measures of the neighbourhood environment for each neighbourhood were adapted from the Neighbourhood Environment Walkability Scale (NEWS), which has been validated in several countries (Saelens et al., 2003). This scale evaluates the neighbourhood environment in various dimensions, including types of residences (e.g. single-family, apartment), accessibility to business (e.g. store, restaurant, library, etc.), streets in the neighbourhood, places for walking and cycling, neighbourhood surroundings/aesthetics, traffic hazards, and crime. Each item was coded using a 4-point scale from strongly disagree to strongly agree. The final score on each dimension of the neighbourhood environment was calculated based on the scoring method provided by Saelens et al. (2003).

In addition to the NEWS, we also included measures on neighbourhood trust/cohesion as a measure of the neighbourhood's social environment. These measures include "People around my neighbourhood are willing to help their neighbours"; "This is a close-knit neighbourhood"; "People in this neighbourhood can be trusted"; "People in this neighbourhood generally don't get along (reverse scored)"; and "People in this neighbourhood do not share the same values (reverse scored)". The measure of social environment was calculated as the mean of the scores on these five items.

Transport Disadvantage

Transport disadvantage was measured using 13 subjective, self-reported measurements, which are adapted from Delbosc and Currie (2011c). Respondents were asked how easy or difficult they find covering transport costs, gaining access to reliable and safe transport, and the extent to which transport enables participation in daily activities. All statements were measured in a five-level Likert scale from "very easy" to "very difficult". Internal consistency among these statements was very high (Cronbach's alpha=0.92). The mean of the scores on these statements was used as the measure of transport disadvantage.

Social exclusion

Social exclusion is a complex and multifaceted concept. Its measurement may include economic, social and political dimensions (Bhalla and Lapeyre, 1997). In this study, social exclusion was measured in three ways: social support from family, friends and neighbours; political engagement; and participation in social activities (including hobbies, sport, and patronage of community facilities and events). Respondents were asked about propensities to seek and receive help from family, friends and neighbours, as well as how often they participate in political and social activities. Some of the survey questions were adapted from Delbosc and Currie (2011c). Each question was coded using a scale of 1 (not at all) to 3 (frequently). The three dimensions of the social exclusion measures are independent from each other and this created three separate measures for social exclusion. Each measure was then calculated as the sum of the scores on the questions related to that dimension.

Physical and mental health

Physical and mental health were measured using the 12-item short form health survey (SF-12), which has been demonstrated to be reliable and valid in the U.S. and other countries (Ware et al., 1996). Exploratory factor analysis was conducted using varimax rotations based on these 12 items, and two factors were extracted to represent physical and mental health respectively. The factor score for each respondent was then used as the measurement.

Subjective well being

Subjective well-being (SWB) was measured using the Satisfaction with Life Scale (SWLS) developed by Diener et al. (1985). SWLS has been widely used and is a global assessment of satisfaction with one's life rather than with specific domains. It has shown strong internal reliability, and moderate temporal stability (Pavot and Diener, 1993). SWLS consists of five items:

- In most ways my life is close to my ideal;
- The conditions of my life are excellent;
- I am satisfied with my life;
- So far I have gotten the important things I want in life;
- If I could live my life over, I would change almost nothing.

Each item was scored using a 7-point Likert scale from strongly disagree to strongly agree. The mean of the scores on the five items was then used for the measurement of SWB.

Demographic Characteristics

Demographic characteristics including age, gender, employment status, household income, educational background, household structure, the number of vehicles owned or rented by the household, the number of bicycles owned or rented by the household, and the number of years the participant had lived in their current neighbourhood.

A descriptive analysis of these variables is provided in Table 3.

Table3 Descriptive analysis of the variables

	N	Minimum	Maximum	Mean	Std. Deviation
Neighbourhood environment					
Density	115	173	776	266.9	122.6
Diversity	115	1	5	3.1	0.7
Accessibility	116	1	4	3.0	0.7
Street connectivity	114	1	4	2.9	0.7
Infrastructure for walking and cycling	116	1	4	3.1	0.5
Aesthetic	116	2	4	2.8	0.7
Traffic	116	1	4	2.6	0.5
Crime	116	1	4	1.9	0.7
Social environment	115	1	4	2.7	0.5
Transport disadvantage					
Transport disadvantage	114	1	5	2.2	0.8
Social inclusion					
Political engagement	117	5	15	6.5	2.2
Social help	117	4	12	9.4	2.0
Social activities	117	5	10	6.3	1.3
Health					
Physical health	110	-2.3	1.5	0.0	1.0
Mental health	110	-2.7	1.6	0.0	1.0
Subjective wellbeing					
SWLS	117	1.4	7.0	4.7	1.2

3.2 Analysis methods

First, ANOVA analysis was conducted to explore significant differences between the four neighbourhoods for our variables of interest (perceived neighbourhood environment, transport disadvantage, social inclusion, physical and mental health, and SWB).

Following the ANOVA tests, further analysis was conducted at the individual level to investigate possible relationships between the key variables listed in Table 3, whilst accounting for the demographic characteristics of the respondents. For this, Structural Equation Modelling (SEM) was employed to test the conceptual model specified in Figure 3 below. This conceptual model was informed by the existing literature and based on our original hypothesis as illustrated in Figure 1 above.

In the model articulated in Figure 3, the hypothesis is that physical and mental health, and social inclusion, have direct effects on SWB, and that transport disadvantage has both a direct *and* an indirect effect on SWB through its influence on physical and mental health, and social inclusion. Demographic characteristics and the neighbourhood environment serve as the exogenous variables, which are hypothesized to influence all of the endogenous variables, including physical and mental health, transport disadvantage, social inclusion and SWB. All the variables in SEM were observed and measured. No latent variables were used in an effort to ensure the model structure remained as parsimonious as possible, given the relatively small sample size.

Although many researchers would recommend a sample size of at least 200 for SEM research (Kline, 2005), several recent simulation studies identify good results from smaller sample sizes. For example, Wolf et al. (2013) demonstrated that a SEM sample size requirement varies between models with the recommendation of sample sizes ranging from 30 cases to 460 cases depending on the model structure, number of latent variables and number of missing values. Similarly, another study (Sideridis et al., 2014) assessed sample size requirement for a SEM with 5 latent variables, each defined by 3 indicators, using Monte Carlo simulation. The results from this study suggested that 70-80 participants were adequate to model the relationships. Further, models with no latent variables require lower sample sizes (Kenny, 2003). To keep the model parsimonious and to reduce the free parameters to be estimated, associations which were not statistically significant or not close to statistically significant ($p<0.1$) and would benefit from a greater sample size in estimation, were deleted from the final SEM model estimation.

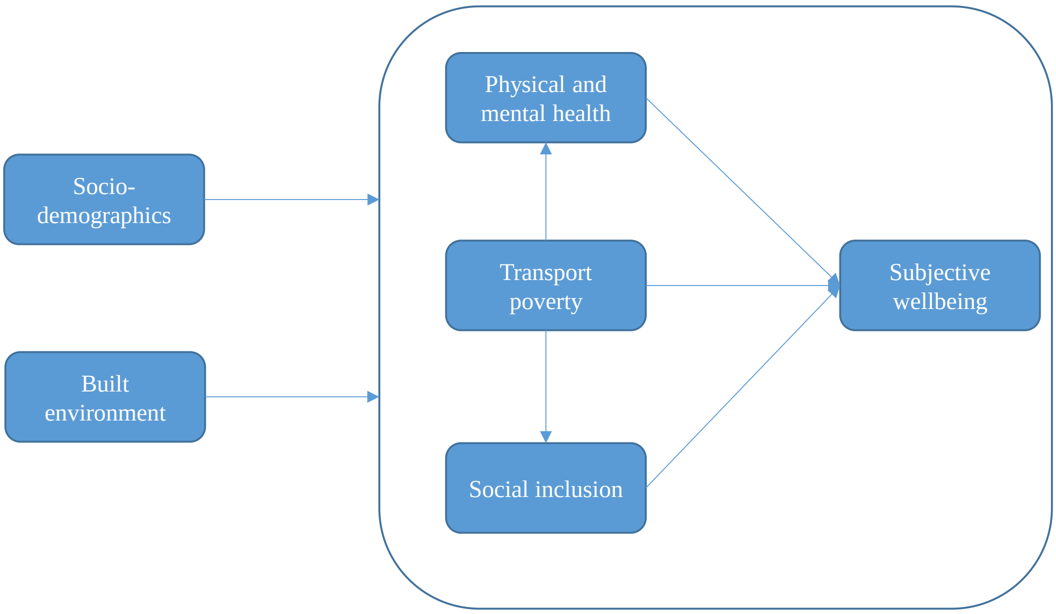

Figure 3 SEM model specification

Results

Table 4 reports the results of ANOVA tests. These aim to explore whether there are significant differences in variables relating to the perceived neighbourhood environment, transport disadvantage, social inclusion, personal health and SWB between the four neighbourhoods. As expected, most of the variables of neighbourhood environment show significant differences between the four neighbourhoods. For example, the respondents from the two very walkable neighbourhoods as defined using our objective indicators (Table 1), Harris Park and Hillsdale, consistently rated higher in density, diversity, accessibility, and street connectivity than respondents from Lansvale, the least walkable neighbourhood. However, the respondents from Lansvale rated higher in neighbourhood aesthetics and social environment but lower in traffic than the respondents from other walkable neighbourhoods. In terms of transport disadvantage, the difference between the four neighbourhoods was only marginally significant, but overall the neighbourhoods with walkable environment and/or good public transport experienced less transport disadvantage than the car-dependent neighbourhood. In terms of social inclusion, none of the three variables were significantly different in means between the four neighbourhoods, suggesting that the role of built environment on social inclusion/exclusion might be weak. For personal health, only physical health was significantly different between neighbourhoods, and respondents from Harris Park (very walkable and good public transport) identified much better physical health conditions than respondents from other neighbourhoods. Finally, the differences in SWB between the four neighbourhoods were not statistically significant. Having said all this, it must be noted that these are results relating to very small samples, particularly in the case of Harris Park and Hillsdale and it would be inappropriate to generalise to other areas.

Table 3 ANOVA tests

	Harris Park (very walkable + good PT)	**Hillsdale** (very walkable)	**Canterbury** (good PT)	**Lansvale** (car-dependent)	p-value
Neighbourhood environment					
Density	370.00	340.75	285.77	184.21	0.00
Diversity	3.43	3.53	3.22	2.69	0.00
Accessibility	3.51	3.22	3.06	2.75	0.00
Street connectivity	3.29	3.00	3.14	2.59	0.00
Infrastructure - walking & cycling	3.22	3.33	3.11	3.04	0.13
Aesthetic	2.54	2.54	2.71	3.03	0.02
Traffic	2.88	2.50	2.60	2.45	0.07
Crime	2.20	1.88	1.82	1.90	0.35
Social environment	2.42	2.67	2.67	2.85	0.05
Transport disadvantage					
Transport disadvantage	2.05	2.10	1.96	2.38	0.09
Social inclusion					
Political engagement	6.36	7.25	6.62	6.20	0.37
Social help	8.86	9.15	9.95	9.27	0.24
Social activities	6.29	6.20	6.38	6.20	0.93
Health					
Physical health	0.65	-0.12	0.15	-0.28	0.02
Mental health	-0.17	0.22	0.06	-0.11	0.60
Subjective wellbeing					
SWLS	4.57	4.41	4.68	4.82	0.60

ANOVA tests reveal preliminary relationships between the built environment and transport disadvantage, personal health and SWB at an aggregate level. However, the neighbourhood environment varies significantly within each neighbourhood, and an individual's response to the neighbourhood environment will also depend on their personal characteristics. To further explore the mechanism of the effects of the built environment, the data are analysed at the individual level. Bivariate correlation analysis is performed between the neighbourhood-environment variables and all of the endogenous variables. The results of these bivariate correlation tests are presented in Table 5. First, a neighbourhood environment having good accessibility to services, more connected streets, and plenty of walking and cycling infrastructure is significantly associated with less transport disadvantage, while higher crime rate in a neighbourhood is associated with higher transport disadvantage. Second, some neighbourhood environment attributes are significantly associated with social inclusion: land-use diversity is positively associated with political engagement. Better walking and cycling infrastructure and social cohesion is significantly associated with more social help. Higher density and diversity are associated with more social activities. Third, higher density and diversity are significantly associated with better physical health, and more walking and cycling infrastructure is significantly associated with better mental health. Fourth, neighbourhood aesthetics, walking and bicycling infrastructure, social trust/cohesion are all significantly positively associated with SWB, while crime rate is significantly negatively associated with SWB. Finally, the interactions between transport disadvantage, social inclusion, personal health and SWB also show interesting results. For example, higher levels of transport disadvantage are significantly associated with less social support, worse physical and mental health, and lower levels of SWB. Surprisingly, political engagement was negatively associated with SWB. Social activities is significantly positively associated with physical health. SWB is only significantly positively associated with mental health, while its association with physical health is not significant.

Table 4 Bivariate correlation tests

	Transport disadvantage	Political engagement	Social help	Social activities	Physical health	Mental health	SWLS
Density	-.056	.170	-.022	.197*	.204*	-.049	-.059
Diversity	-.141	.184*	-.115	.205*	.238*	.005	-.067
Accessibility to services	-.430**	.087	.021	.120	.187	.010	.130
Street connectivity	-.324**	.064	.053	.054	.117	.048	.035
Infrastructure (walking and cycling)	-.359**	-.067	.307**	-.034	.054	.215*	.291**
Aesthetically pleasing neighbourhood	-.099	.061	.134	.044	-.169	.016	.317**
Traffic	.030	-.069	-.016	-.137	-.025	.092	-.084
Crime	.281**	-.030	-.093	.030	.077	-.077	-.206*
Social environment	-.110	.107	.198*	-.039	-.003	.091	.205*
Transport disadvantage	1	-.052	-.250**	-.079	-.296**	-.395**	-.271**
Political engagement		1	-.079	.292**	.167	-.151	-.203*
Social help			1	.097	.025	.183	.158
Social activities				1	.195*	.047	.103
Physical health						.000	.087
Mental health						1	.355**
SWLS							1

*p<.05; **p<.01

The SEM model is estimated using full information maximum likelihood (FIML) to confirm the associations identified from bivariate correlation tests and to explore the structural relationships between the variables. The results are presented in Table 6. Various model specifications have been tested before developing the final model. For example, the variables, *street connectivity*, *social environment*, and *traffic* are eliminated from the final model, because they were not statistically significant at the10 per cent level in any tested models.

Overall, the model is a good fit to the data. The chi-square value was insignificant, χ^2 (6) =7.917, p=.244. Alternative fit indices were also examined to determine whether the fit was adequate. The alternative fit indices suggested a good fit according to the criteria presented in Hu and Bentler (1999) with CFI=.994, SRMEA=.052. Overall, the model explains about 31.2%, 12.9%, 19.1%, 14.7%, 27.5%, and 40.2% of the variations in transport disadvantage, political engagement, social help, social activities, physical health, mental health and SWB respectively.

As expected, the demographic characteristics of the respondents are associated with most of the endogenous variables. For example, women are more likely to participate in social activities than men. Older adults are more likely to have worse physical health but higher level of SWB than younger adults. The positive association between age and SWB has also been found in other studies (Cao and Ettema, 2014; Diener and Suh, 1997). Low-income households are more likely to engage in political activities. While this contrasts with the findings of some previous literature, low-income residents might have more unmet needs and are therefore more motivated to engage in political activities to influence decision making. Those who are employed were more likely to have better mental health, and higher levels of SWB than those who are unemployed. Households with more vehicles are less likely to experience transport disadvantage. As most of households (90%) in the sample owned a car, there was no significant association between car availability and each of the three measures of social inclusion, though previous studies (Currie et al., 2009; Lucas, 2012; Ong and Miller, 2005) have highlighted the importance of car ownership in facilitating social inclusion.

Many of the neighbourhood environment variables are significantly associated with the endogenous variables, even after controlling for demographics of the respondents. Those living in high density neighbourhoods are more likely to participate in social activities. Those living in neighbourhoods with more diverse land uses are more likely to engage in political activities, and to participate in social activities. Better accessibility to services is associated with less transport disadvantage. Those living in neighbourhoods with better infrastructure for walking and cycling are less likely to experience transport disadvantage and participate in more social activities, but less political engagement. An aesthetically pleasing neighbourhood (the presence of street trees, interesting destinations, attractive natural sights and buildings) is positively associated with SWB. Residents in neighbourhoods with perceived high crime rates have higher levels of transport disadvantage and lower levels of SWB than others. In addition, none of the built environment characteristics are significantly associated with physical and mental health, though some of these relationships were significant in bivariate correlation tests shown in Table 5.

Finally, most of the relationships between transport disadvantage, social inclusion and SWB found in the SEM model results are consistent with the findings from the bivariate correlation analysis. Transport disadvantage is negatively associated with social help, and with physical and mental health. It does not, however, have direct impact on SWB. This is contrary to the hypothesis shown in Figure 3. Political engagement is negatively associated with SWB. While this is unexpected, a previous study (Lorenzini, 2015) suggested that the causal direction may run from SWB to political engagement and argued that life dissatisfaction might foster the participation in political activities to express this dissatisfaction. Supportive of this is the way in which the sample was generated in the run up to a Federal election where there appears to be general satisfaction with all potential political outcomes. Both social help and social activities are not significantly associated with SWB. To the contrary, both physical and mental health are positively associated with SWB.

Table 5 SEM results

	Transport poverty		Political engagement		Social help		Social activities		Physical health		Mental health		SWLS	
	Std. Coeff.	p-value	Std. Coeff.	p-value	Std. Coeff.	p-value	Std. Coeff.	p-value	Std. Coeff.	p-value	Std. Coeff.	p-value	Std. Coeff.	p-value
Female	0.108	0.195	0.073	0.435	0.093	0.303	**0.197**	**0.034**	-0.044	0.615	-0.027	0.765	-0.004	0.961
Age	-0.104	0.303	-0.023	0.841	0.005	0.966	0.132	0.239	**-0.213**	**0.043**	0.129	0.233	**0.396**	**0.000**
# vehicles	**-0.207**		-0.058	0.574	0.141	0.155	0.021	0.833	-0.109	0.253	-0.031	0.749	0.062	0.478
HH income	-0.043	0.689	**-0.226**	**0.059**	-0.014	0.906	0.188	0.112	0.088	0.429	-0.051	0.657	-0.039	0.708
Employed	0.096	0.397	0.079	0.536	0.052	0.674	0.026	0.835	0.085	0.473	**0.252**	**0.038**	**0.244**	**0.025**
Density	-0.083	0.362	0.134	0.189	0.051	0.602	**0.200**	**0.047**	-0.010	0.915	-0.119	0.223	0.038	0.660
Diversity	-0.069	0.463	**0.177**	**0.094**	-0.114	0.262	**0.184**	**0.078**	0.036	0.713	-0.038	0.704	-0.010	0.916
Access	**-0.274**	**0.003**	0.018	0.870	-0.113	0.278	0.054	0.617	0.045	0.662	-0.165	0.114	0.046	0.617
Infrastructure	**-0.244**	**0.009**	**-0.210**	**0.051**	**0.311**	**0.003**	-0.099	0.350	0.035	0.731	0.149	0.149	0.023	0.809
Aesthetic	0.035	0.686	0.149	0.129	0.003	0.971	0.104	0.281	-0.150	0.103	-0.037	0.691	**0.335**	**0.000**
Crime	**0.166**	**0.063**	-0.069	0.494	0.103	0.293	0.016	0.870	0.075	0.437	0.130	0.170	**-0.159**	**0.064**
Transport poverty			-0.073	0.490	**-0.236**	**0.021**	-0.058	0.579	**-0.360**	**0.000**	**-0.460**	**0.000**	-0.041	0.697
Political engagement													**-0.255**	**0.002**
Social help													-0.004	0.960
Social activities													0.113	0.172
Physical health													**0.188**	**0.034**
Mental health													**0.209**	**0.016**
R2	0.312		0.129		0.191		0.147		0.275		0.242		0.402	

Note: bold font indicates p<.1

Conclusions

This study explores the effects of the built environment on transport disadvantage, social exclusion, personal health and SWB using survey data collected in four socio-disadvantaged neighbourhoods in Sydney, Australia. The data is analysed at both neighbourhood and individual levels using both descriptive analysis and structural equation modelling (SEM). The results offer insights on the connections between the built environment, transport disadvantage, social exclusion, health and SWB.

The aggregate level analysis reveals that residents in neighbourhoods with walkable environments and/or good public transport, experience less transport disadvantage than car-dependent neighbourhoods. Residents of Harris Park (the most walkable neighbourhood with good public transport) have better physical health than the residents of the other three neighbourhoods although based on an extremely small sample. However, the effects of neighbourhood environment on social exclusion and SWB is very weak or not significant.

The individual level analysis further unpacks various design elements of the built environment into different dimensions. Overall, our model supports the hypothesis that a walkable neighbourhood environment, measured by density, diversity, access, and infrastructure for walking and cycling, helps to reduce transport disadvantage and increase social inclusion. However, the impact of the physical environment does not carry forward to impact personal health and SWB. The exception to this finding is where the environment is perceived to be aesthetically pleasing – a variable which significantly positively affects SWB. In addition to the physical environment, crime is a significant factor that directly influences transport disadvantage and SWB. Consistent with previous literature (Currie et al., 2010; Lucas, 2012), transport disadvantage prevents social inclusion (as measured by social help) and leads to lower physical and mental health. In terms of the associations between social inclusion and SWB, political engagement has significant and negative effects on SWB. Finally, both physical health and mental health have significant and positive effects on SWB

This study has some limitations. First, given the funding budget, only 1,600 households within four neighbourhoods were targeted. The resulting small sample size limits the generalisability of the findings of this study. More studies or larger sample sizes are needed to compare the findings of this study and to make robust recommendations for policy. Second, this study only includes perceived measures of the neighbourhood environment. It is well known that objective measures and perceived measures of the built environment are not well matched (Ma and Dill, 2015; Van Acker et al., 2013), and both approaches may have independent effects on transport disadvantage, social inclusion, health and SWB which have not been tested in this study. Third, longitudinal studies are necessary to make rigorous causal inferences among such factors as the built environment, transport disadvantage, social inclusion, health and SWB. Of course, such data is very difficult to access for analysis.

Our final recommendation is that future research on social exclusion should separate aspects of social inclusion from social exclusion in measurement. The aspects used in this study (political engagement, social help and social activities), are independent and appear to have low internal consistency. Combining these aspects can distort results.

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