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Neighbourhood built environment and walking behaviours: evidence from the rural American South

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Abstract

This study examines the perceived neighbourhood characteristics and environmental barriers in association with two different types of walking - recreational and destination - in the context of a rural town in Mississippi. A cross-sectional survey was used to assess residents' walking behaviours, perceived neighbourhood characteristics, and perceived environmental barriers to walking in three types of neighbourhoods: traditional, early conventional suburban and late conventional suburban. Descriptive statistics, one-way analysis of variance (ANOVA) and regression analyses identified environmental factors correlated with walking. A total of 362 surveys were completed and returned by random adult members of the households contacted, for a 38.5% response rate. Perceived aesthetics are significantly associated with more frequent recreational and destination walking in this rural town. Higher perceived accessibility are associated with more frequent destination walking, and greater perceived social environment barriers to walking are associated with sedentary behaviour in the rural population studied. Of all factors related to a neighbourhood's built environment, the most important factor in promoting walking in rural towns is aesthetics. The relationships among accessibility, social environment and walking underscore the importance of community planning in incorporating mixed land uses, providing a connected pedestrian infrastructure and facilitating targeted social interventions to encourage more walking.

Keywords

Neighbourhood built environment; walking behaviour; rural area; perceived neighbourhood characteristics; recreational walking; destination walking

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Authors' Contributions

Dr. Li initiated the study conception and design. She worked with Robert Jackson in the acquisition of data. Dr. Chi conducted data analysis with the assistance of Robert Jackson and designed data analysis. Both Dr. Li and Dr. Chi interpreted data and drafted the manuscript. All the authors read, commented and approved the final manuscript.

Declaration of Conflicts of Interest

The authors declare no potential conflicts of interest with respect to the researcher, authorship, and/or publication of this article.

Introduction

Researchers have established a causal relationship between physical activity and improved public health, although many other factors such as diet, types of physical activity and lifestyle are also correlated with health.[1,2] Walking is one of the most popular forms of physical activity; thus, environmental design or planning that promotes walking has an important health implication.[3,4] Research suggests that different characteristics of the environment - natural, built and/or perceived - are associated with different types of walking, such as walking for leisure or for transport.[5,6]

The neighbourhood is one of the primary public places where walking occurs. Studies show that certain environmental attributes or categories at the neighbourhood scale have been associated with walking. However, little is known about variations across different neighbourhood types. Moreover, existing literature has been geographically focused on urban areas, while rural areas - which differ considerably from urban areas in terms population density, built-environment characteristics and socioeconomic composition - remain largely understudied.[3] This study attempts to fill the gap in the literature by analysing the built environment of neighbourhoods and walking behaviours in the rural American South town of Starkville, Mississippi. Three types of neighbourhoods were chosen for this study: traditional, early conventional suburban and late conventional suburban. Through comparative analysis of the three types of neighbourhoods, this study examines how perceived neighbourhood characteristics and perceived walking barriers for different types of neighbourhoods correlate with walking for different purposes in a rural setting.

Literature Review

Many studies in urban planning and transportation have investigated the influences of various environmental factors on walking for transport-related or recreational purposes. Studies found consistent associations between the built environment and walking for transport (also referred to as destination walking).[2] Walking for transport is most significantly associated with the presence and proximity of destinations,[7,8] street connectivity,[9] maintenance of sidewalks[10] and higher residential density.[11] Bessor and Dannenberg,[12] for instance, suggested that people in high-density urban areas were more likely to walk more than 30 minutes to and from transit daily. For trips walking to the store, factors such as proximity to the store, pedestrian connectivity and less perceived traffic were associated with higher walking frequency.[13] A study conducted in cities in Belgium and Portugal found walking for transport related to higher land-use mix, residential density, availability of sidewalks and connectivity.[14] Frank[11] similarly suggested that walkability that incorporated land-use mix, street connectivity, net residential density and retail-floor-area ratio was associated with greater time spent walking for transport. Some other studies found consistent association between destination walking and aesthetics, traffic and personal safety.[3,15,16]

The association between the built environment and recreational walking was less clear. Lee and colleagues[17] argued that physical environmental variables had a stronger association with transportation walking compared with recreational walking. Researchers also found that the environmental variables highly related with recreational walking may not influence transportation walking, and vice versa.[17,18] Rutt and Coleman,[18] for example, reported that more commercial land uses in a neighbourhood were associated with a higher frequency of walking for transport, while residents in neighbourhoods with less commercial land use tended to spend more time walking for exercise. Studies have documented consistent positive relationships between recreational walking and the presence of or proximity to destinations,[7,19] although Handy[6] found that accessibility to stores and other destinations has no influence for recreational trips. Only modest evidence has been found for the importance of street connectivity and the maintenance of sidewalks as factors in recreational walking.[15,20] However, some studies identified a significant association between aesthetics, pedestrian infrastructure and recreational walking.[21,22] Longer sidewalks, greater slope and having interesting architecture to look at, for example, were found to be positively associated with recreational walking.[17] There is also evidence that greater perceived neighbourhood safety is related to more walking for exercise or walking dogs.[23]

Previous studies have examined the distinctions between urban and rural areas in supporting walking for different purposes. Respondents from urban areas reported more walking for transport compared with those from rural areas. Walking for recreation or exercise was also more likely among male residents in urban areas.[24] Another study classified adult trips by five urbanization categories - urban, second city, suburban, town and rural. It suggested that walking trips for transportation were less prevalent among rural and town residents and residents of the U.S. South.[25]

These studies provide a critical understanding of how environmental factors are associated with walking for different purposes. But the questions remain: How does the built environment in a rural setting affect walking behaviours differently, compared with urban areas? How do different neighbourhood types support or discourage walking for various purposes? The current study aims to answer these questions by focusing on a rural town in the U.S. South and comparing walking behaviours in three types of neighbourhoods. It examines the various neighbourhood characteristics associated with walking for different purposes.

Methods

Study Site

The city of Starkville, Mississippi, has a population of 23,888 and is categorised as a rural area by the U.S. Bureau of Census in 2010.[26] The median income for a household in the city is $31,357, and the population density is 936.4 people per square mile. The city's population has 59.6% non-Hispanic White, 34.6% Black, and 3.7% Asian populations. About 51.3% of occupied housing units are detached single-family homes, and 68.5% were built between 1960 and 1999. About 92.4% of the households own one or more than one vehicles, and the mean travel time to work is 19.1 minutes[26] (Fig. 1). The study chose three neighbourhood types because they represented the majority of the neighbourhood developments in the city of Starkville. Two middle-income neighbourhoods of each of the three neighbourhood types were used as study sites (Fig. 2).

Table 1 shows the objective measurement of the neighbourhood characteristics. The two traditional neighbourhoods studied in this research - Greensboro and Overstreet - were built between 1870 and 1940. They are among the earliest residential developments in the city of Starkville (Fig. 3). They share features such as proximity to the central commercial area and have varied lot sizes, narrow streets with sidewalks, mature trees, a variety of house styles and smaller street setbacks (the distance from the building property line to the street).

The two early conventional suburban neighbourhoods studied in this research - Greenbriar and Timbercove - were developed after World War II. The first houses in those neighbourhoods were built in 1971 and 1978, respectively. As planned communities, they feature segregated land uses, homogenous lot sizes and house styles, wide streets without sidewalks, small trees and large street setbacks.

The two late conventional suburban neighbourhoods - Huntington Park and Country Club Estates - are relatively new developments that were built in and after the 1990s. They share some similarities with the early conventional suburban neighbourhoods, including a cul-de-sac street network, small trees and a relatively low degree of variety in housing styles, but they are equipped with sidewalks and have smaller lot sizes and include shared open spaces, such as lakes.

Survey

A cross-sectional survey was used in this study to assess walking behaviours and residents' perceptions of their neighbourhoods. Letters informing residents about this study were mailed at the end of August 2012. Two weeks later, 990 surveys were mailed to all the households in the six neighbourhoods; 292 survey responses were returned. A reminder postcard was sent two weeks after the initial survey mailing. A second round of 698 surveys was mailed in late September to households that did not respond the first time; 70 surveys were returned after the second mailing. Ultimately, 362 surveys were completed and returned by an adult member of the households contacted, for a 36.6% response rate. After assessing the completeness of each survey response, 289 (79.8% of the returned surveys) were used for this study.

The survey consisted of four parts: self-reported physical activity, residents' perceptions of neighbourhood characteristics, residents' perceptions of environmental barriers to walking and sociodemographic information. The first section of the survey solicited self-reported walking behaviours. A modified version of the International Physical Activity Questionnaire (IPAQ)[27] was used to measure the frequency of walking. A survey question asked the respondents to indicate how many days they had walked in the past seven days for leisure and for transportation purposes. Reported walking was limited to walks of 10 minutes or more, which is consistent with physical activity guidelines.[27–29] The use of a week-long time period captured regular walking activities and variations in time of day and short-term weather changes.[27]

The second section of the survey assessed residents' perceptions of neighbourhood characteristics, which were grouped into four indices: accessibility, traffic-safety features, aesthetics and social environment. Participants rated their level of agreement with 19 statements about their neighbourhood, such as 'My neighbourhood has low amounts of vehicle traffic', on a 5-point Likert-type scale (1 = strongly disagree to 5 = strongly agree).

The third part of the survey focused on the perceived environmental barriers to walking in the neighbourhood. Among the 19 environmental barriers assessed in the survey were poor accessibility, lack of traffic safety, poor aesthetics and unfriendly social environment. The survey asked the respondents to rate statements such as 'I feel uncomfortable walking in my neighbourhood because it has high amounts of vehicle traffic' from 1 to 5 (1 = strongly disagree to 5 = strongly agree), with higher scores indicating a more unfavourable value for the environmental characteristics. All the variables in the second and third parts of the survey were assessed on a neighbourhood scale.

The survey also collected self-reported person-level data on gender, age, education, household income and employment status. The study instruments were approved by the Institutional Review Board at Mississippi State University.

Analyses

Descriptive statistics and one-way analysis of variance (ANOVA) were conducted to compare the amount of walking, perceived neighbourhood features, perceived environmental barriers to walking and demographic and socioeconomic variations among the three types of neighbourhoods - traditional, early conventional suburban and late conventional suburban.

Regression models were employed to examine the associations of recreational and destination walking with perceived neighbourhood characteristics and perceived walking barriers, controlling for sociodemographic variables. We fitted the models separately for recreational and destination walking for all neighbourhoods and for each of the three neighbourhood types.

For recreational walking, negative binomial regression models were used. Recreational walking was measured as a frequency (i.e., the number of days per week) of recreational walking and was count data. Count data can be modelled by Poisson regression or negative binomial regression models. If the variable exhibits over dispersion - that is, the variance is larger than the mean - negative binomial regression models are more appropriate.[30] Recreational walking exhibited over dispersion (variance larger than the mean) for all neighbourhoods and each of the three neighbourhood types.[31] Therefore, negative binomial regression models were chosen to analyse the association of recreational walking with perceived neighbourhood characteristics and barriers, controlling for sociodemographic variables.

For destination walking, we used logistic regression models. Destination walking was initially also measured as a frequency. However, the frequency of destination walking was generally low - on average, respondents walked 1.63 days per week for transportation purposes; 60% of the respondents did not make any on-foot trips to specific destinations (Table 2). We converted the frequency of destination walking to a dichotomous variable, with 0 representing no walking at all and 1 representing walking at least once per week. We subsequently fitted logistic regression models to analyse the association of destination walking with neighbourhood perceptions, perceived barriers and sociodemographic controls.

Results

Descriptive Statistics

No statistically significant differences in the frequency of recreational and destination walking were observed among the three types of neighbourhoods (Table 2). However, when measured as a dichotomous variable, with 0 representing no walking at all and 1 representing walking at least once per week, more destination walking occurred in the traditional neighbourhoods than in the other neighbourhoods.

Of the three types of neighbourhoods, the traditional ones received the highest scores on accessibility and aesthetics, while the late conventional suburban neighbourhoods scored the highest in terms of traffic safety and social environment. The differences among the perceived neighbourhood features of the three neighbourhood types are statistically significant (Table 3).

Perceived barriers to walking differed significantly by neighbourhood type. Residents from traditional neighbourhoods scored traffic safety and unsupportive social environment as more significant walking barriers, while respondents from the early conventional suburban neighbourhoods rated poor accessibility and aesthetics as more important walking barriers (Table 4).

The respondents had a mean age of 53.8 years, with 57.96% females and 89.52% self-claimed as White; 49% of the respondents were fully employed (Table 5).

Regression Analysis of Recreational Walking

Table 6 presents the negative binomial regression results of recreational walking for all neighbourhoods, traditional neighbourhoods, early conventional suburban neighbourhoods and late conventional suburban neighbourhoods.

When all neighbourhoods were examined together, recreational walking was positively associated with perceived aesthetics. Social environment barriers to walking were significantly associated with recreational walking when controlling for sociodemographic factors. Age was also positively associated with recreational walking, as recreational walking frequency increased with increasing age.

When models were estimated for each neighbourhood type individually, the associations varied. For traditional neighbourhoods, perceived accessibility showed a negative association with recreational walking. Aesthetics was positively associated with recreational walking when controlling for sociodemographic factors and perceived walking barriers. Age had a positive association with recreational walking. In early conventional suburban neighbourhoods, both perceived traffic safety and aesthetics had positive associations with recreational walking. For late conventional suburban neighbourhoods, age and education had positive associations with recreational walking, while employment had a negative association with recreational walking.

Regression Analysis of Destination Walking

Table 7 presents the logistic regression results of destination walking for all neighbourhoods, traditional neighbourhoods, early conventional suburban neighbourhoods and late conventional suburban neighbourhoods. The coefficients for logistic regression models are odds coefficients, meaning that the effect is positive if a coefficient is larger than 1 and the effect is negative if a coefficient is less than 1.

When models were estimated for all neighbourhoods, destination walking was positively associated with perceived accessibility and aesthetics. Perceived social environment as a walking barrier was negatively associated with destination walking. For the sociodemographic factors, income was negatively associated with destination walking.

When models were estimated for traditional neighbourhoods, none of the variables had a statistically significant association with destination walking. For the early conventional suburban neighbourhoods, perceived aesthetics and employment had a positive association with destination walking, while higher perceived social environment barriers were associated with a lower frequency of destination walking. In the late conventional suburban neighbourhoods, perceived traffic safety, age and education were stronger promoters of destination walking. Accessibility as a perceived walking barrier was negatively associated with destination walking.

Discussion

Neighbourhood Comparison of Walking

A comparison of the three types of neighbourhoods yielded some interesting insights into walking behaviours in the context of a small rural town in the American South. Previous studies found residents of traditional/high-walkable neighbourhoods reported higher walking frequency than residents of conventional/low-walkable neighbourhoods. Traditional/high-walkable neighbourhoods were characterised by high population density, a good mixture of land uses, high street connectivity and adequate pedestrian facilities.[32] In our study, however, the findings showed no statistically significant difference in the frequency of walking trips per week between traditional neighbourhoods and conventional neighbourhoods. The differences of the findings might be due in part to the generally low population density in Starkville. As shown in Table 1, no significant differences of residential density exist among the three types of neighbourhoods. Although the traditional neighbourhoods in our study had a good mixture of land uses, highly connected streets and continuous sidewalks, residential density was among the most consistently positive variables correlating with walking trips,[3,33] especially for destination walking.[34]

Consistent with previous studies that showed residents of rural areas have much lower rates of walking to destinations compared with residents of urban areas,[35,36] our study found generally low rates of destination walking in Starkville. These low rates probably contribute to the lack of significant differences in walking trips between the traditional and conventional suburban neighbourhoods in our study. Handy[6,37] suggested that destination walking was the dominant factor related to differences in walking frequency in traditional and suburban neighbourhoods but did not find significant differences in terms of frequency of recreational walking. Thus, although neighbourhood types are correlated with walking frequency, low residential density in a rural setting tends to discourage destination walking and consequently weakens the benefits of traditional/high-walkable neighbourhoods in facilitating walking trips. Further study is necessary to understand the weighting of different built-environment factors in affecting walking choices.

Neighbourhood Characteristics and Walking

In the context of the rural community, perceived aesthetics was consistently associated with higher frequency of walking for both recreational and destination purposes. The strength of aesthetics in predicting recreational walking has been noted previously,[38] but little or no evidence from prior studies found an association between aesthetics and destination walking. This might partly be because most studies focused on urban areas. One of the few studies of rural areas suggested that of all environmental factors, only the absence of enjoyable scenery was associated with sedentary behaviour in rural women, especially women in the U.S. South and less-educated women.[39] The results of our study also suggest that of all variables related to a neighbourhood's built environment, aesthetics is most strongly associated with the frequency of walking by residents of Starkville. Thus, an attractive neighbourhood environment and community-based greening efforts may generate important benefits for residents and communities by providing a more supportive walking environment.

Our findings also show that higher perceived accessibility is significantly associated with a higher frequency of destination walking in Starkville. In models examining each type of neighbourhood separately, however, ease of accessibility was negatively associated with recreational walking in the traditional neighbourhoods. This finding differs from those of previous studies, which found a positive association between recreational walking and the presence of or proximity to either utilitarian or recreational destinations.[13,28,40] This result might be explained by the fact that the central locations of the traditional neighbourhoods in Starkville provide convenient access to stores and recreational facilities (see Table 1), but at the same time traffic from outside those neighbourhoods increases with such access, which intensifies concerns about safety and thus tends to discourage people from walking for recreational purposes. Our finding echoes Rutt and Coleman's[18] research that found neighbourhoods with less commercial land use tended to encourage recreational walking. Furthermore, a previous study found that gridded street networks (as in the traditional neighbourhoods) tend to have more traffic accidents with injuries compared with cul-de-sac communities.[41] The objective measurements in Table 1 also show that traditional neighbourhoods have lower street-lighting coverage compared with the other two types of neighbourhoods, although the difference was not statistically significant. Consequently, high amounts of vehicle traffic, densely distributed street intersections and relatively lower street-lighting coverage in the traditional neighbourhoods resulted in a perceived lack of traffic safety and was associated with less frequent walking than in the conventional suburban neighbourhoods. Improved access to destinations and public transportation is just as vital in rural communities as in urban areas. But a planning intervention in improving perceived traffic safety also appears to be crucial in encouraging walking in a rural setting.

Perceived Environmental Barriers and Walking

With regard to perceived environmental barriers to walking, residents in all the neighbourhoods who reported a higher score on perceiving the social environment as a barrier tended to walk for recreation less frequently. The social environment also appeared to present barriers to destination walking in all the neighbourhoods. This finding echoes previous studies of rural communities that showed seeing others exercising more frequently was positively associated with physical activity among rural but not urban or suburban residents.[39,42] Leyden's[43] study indicates that residents in walkable, mixed-use neighbourhoods were more likely to know their neighbours, participate politically, trust others and be socially engaged compared with those living in car-dependent suburbs. In our study, however, traditional neighbourhoods did not receive higher scores in social environment compared with conventional suburban neighbourhoods. The reasons are complicated because of the particular development pattern of the rural town centre. In general, the traditional neighbourhoods in our study setting have a relatively younger and more diverse population, and the neighbourhoods are proximate to many rental properties for the central locations. Thus, further study is required to examine the impact of factors such as surrounding land uses and demographic composition on the perceived social environment in a rural setting.

Research suggests that creating small parks and common public spaces in a neighbourhood could stimulate more social contact and that the quality and amenities of public spaces within a neighbourhood affect its sense of community and social cohesion.[44] In a low-density rural area, this approach is particularly relevant because rural communities have a higher concentration of older adults and low-income citizens, two segments of the population who need high-quality options in terms of public facilities and infrastructure.

Demographic Variations and Walking

Some sociodemographic factors were found to be predictors of walking in Starkville. Age was positively associated with recreational walking. Older people tended to walk more. This result is in contrast with previous studies, which found that older age contributes to a decrease in walking.[6] Age has also appeared to be more strongly associated with destination walking than recreational walking.[42] These differences might be explained by geographical variations of rural and urban areas. Further study is needed for an improved understanding of the demographic variables associated with walking behaviours in urban and rural areas.

Employment status was correlated with destination walking in the early conventional suburban neighbourhoods studied in Starkville. Residents who are employed tended to walk more frequently for transport purposes but less for recreational purposes, possibly because of the limited recreational time available to them. These results were in contrast with those of some previous studies, which found that unemployed residents were nearly twice as likely as employed residents to walk to a store.[42] Again, further study on the sociodemographic factors in rural and urban areas might help explain these differences.

Four limitations of this study must be acknowledged. First, the study, which was cross-sectional, measured a relatively small sample in one particular rural town. The number of observations in the traditional and late conventional suburb neighbourhoods are small, affecting the reliability of the regression results. More data could be collected in multiple rural areas to evaluate environmental influences on physical activity. Second, the reliance on self-reported physical activity is another limitation of this study. An objective measurement of physical activity would enhance the reliability of the results. Third, there are strong correlations (in terms of both magnitude and statistical significance) among the four barrier measures. A future survey should try to avoid overlap among these four measures. Fourth, this research suffers from the residential self-selection issue because the sociodemographic variables (e.g., median age, income and education) vary across the three neighbourhood types. The self-selection issue could be addressed by a careful comparison and selection among direct questioning, statistical control, instrumental variables models, sample-selection models, joint discrete-choice models, structural equations models and longitudinal designs.[45]

Conclusions

This study identified neighbourhood characteristics that are associated with walking for different purposes in an area of the rural U.S. South. The analyses identified variations in recreational walking and destination walking in different neighbourhood types and some of the unique conditions of rural areas as compared with urban communities. The findings point to a need for policy and environmental interventions tailored to specific needs in rural areas. The study emphasises that new developments or neighbourhood revitalizations could improve aesthetics in community design.

The relationship between accessibility and destination walking underscores calls for collaborative efforts among city planners, real estate developers and health professionals to promote mixed land uses and pedestrian infrastructures that connect neighbourhoods with desirable destinations. The association between perceiving the social environment as a barrier and the frequency of recreational and destination walking suggests that community planning should incorporate public open spaces and facilitate targeted social interventions. Such efforts would help increase the social capital of the community and, as a consequence, promote walking, social interaction, and well-being in rural communities.

This research could be extended in three directions. First, future studies of both macro and micro levels of environmental attributes in rural areas are needed to identify attributes that account for differences in walking behaviours in rural and urban areas. Specifically, future studies should more closely examine the objective measures of rural built environments as well as sociodemographic characteristics. Such an examination combined with a comparative study of rural and urban areas could provide more comprehensive tools to evaluate the local walkability of particular areas with respect to regional and contextual variations and thus provide information for designing environmental and policy interventions that target lesser studied groups. Second, multilevel modelling could be used to better capture the effects of both individual characteristics and physical environment measures. Third, the structural equation modelling method could be adopted to address the relationships between variables, patterns of their relationships and patterns of their impact on walking with a larger number of respondents.

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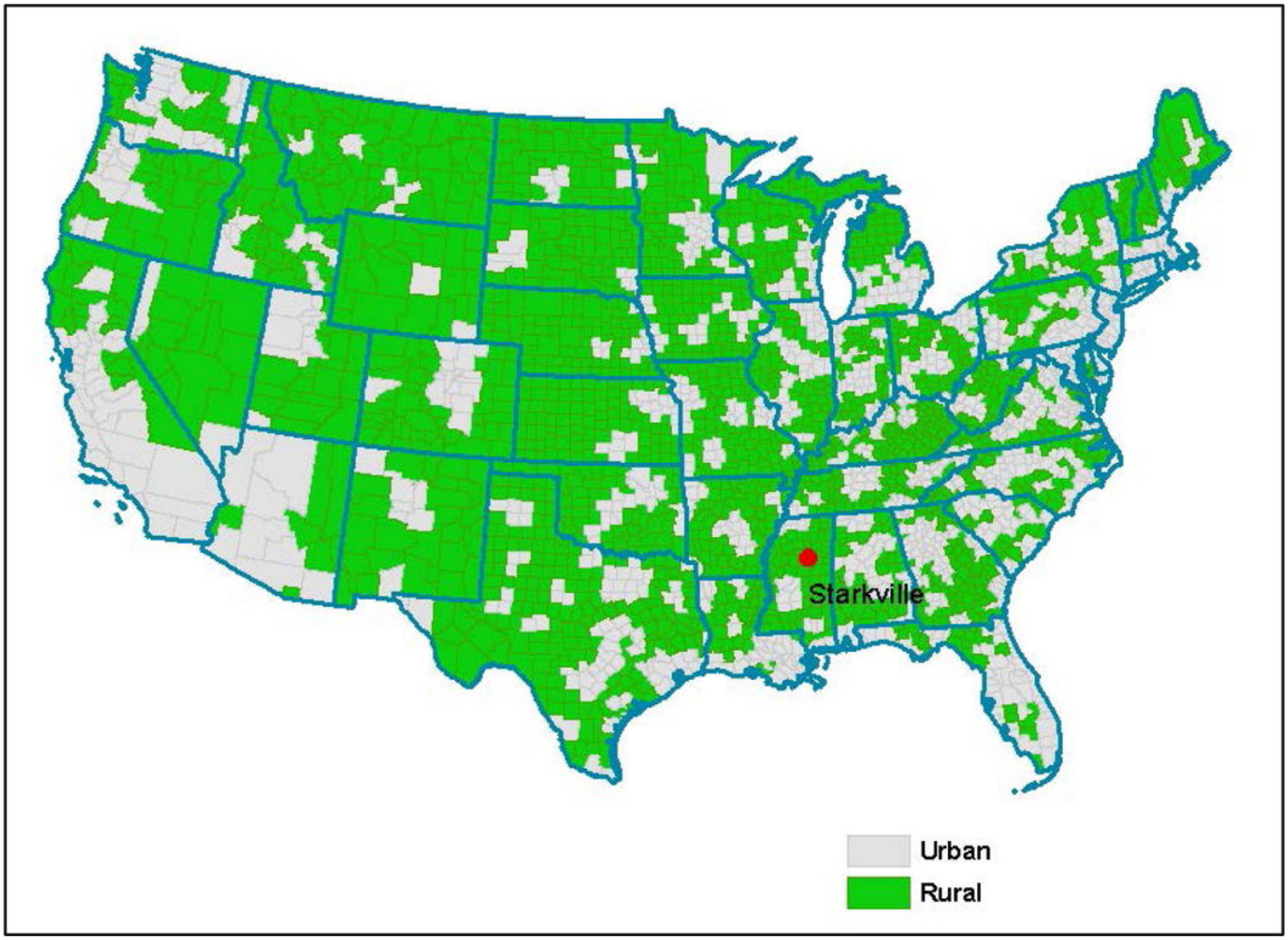

Fig. 1.
Location of the city of Starkville, Mississippi. (The map was created based on the *2013 Rural-Urban Continuum Codes* provided by the U.S. Department of Agriculture)

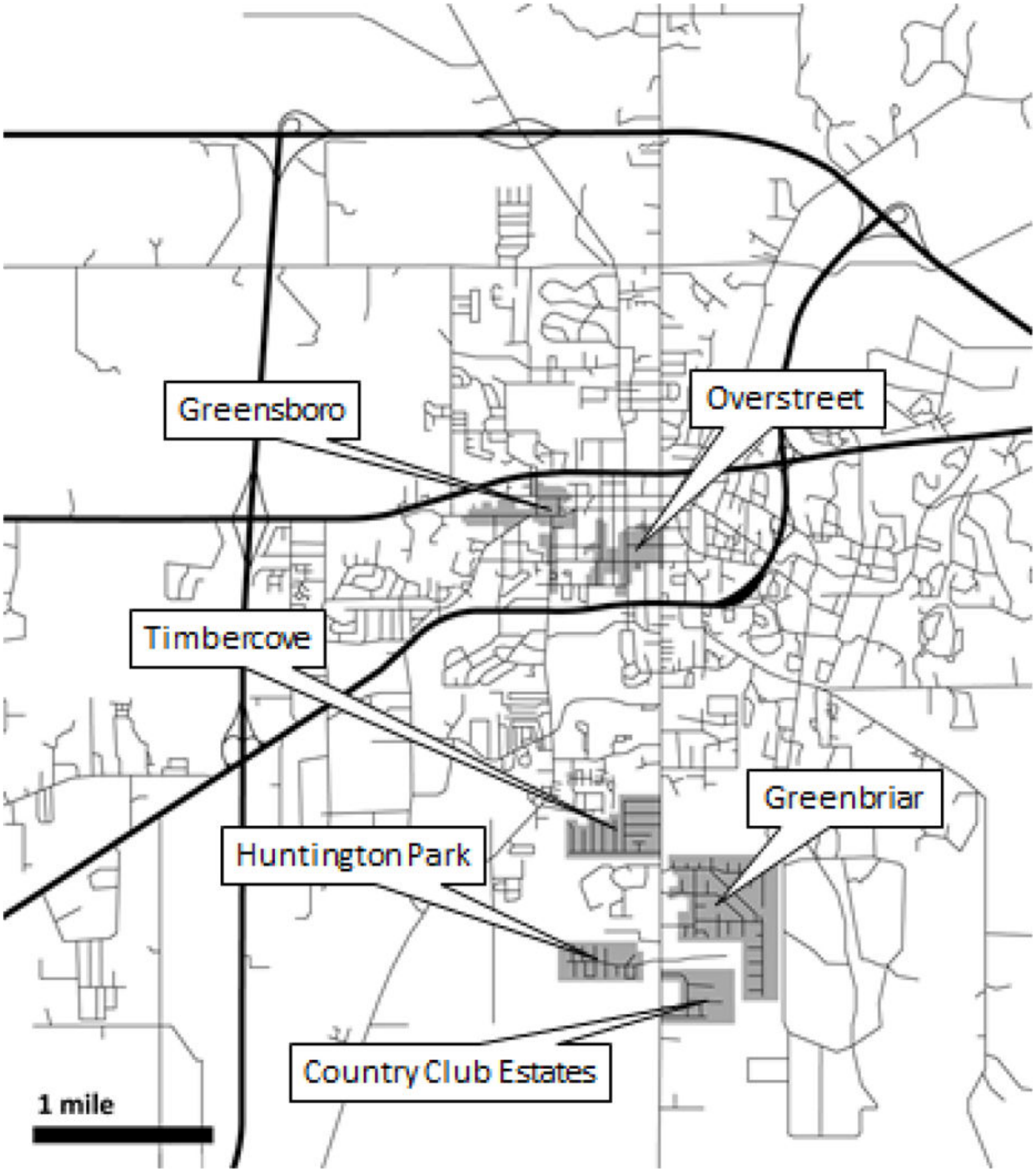

Fig. 2.

Locations of the six neighbourhoods in the study.

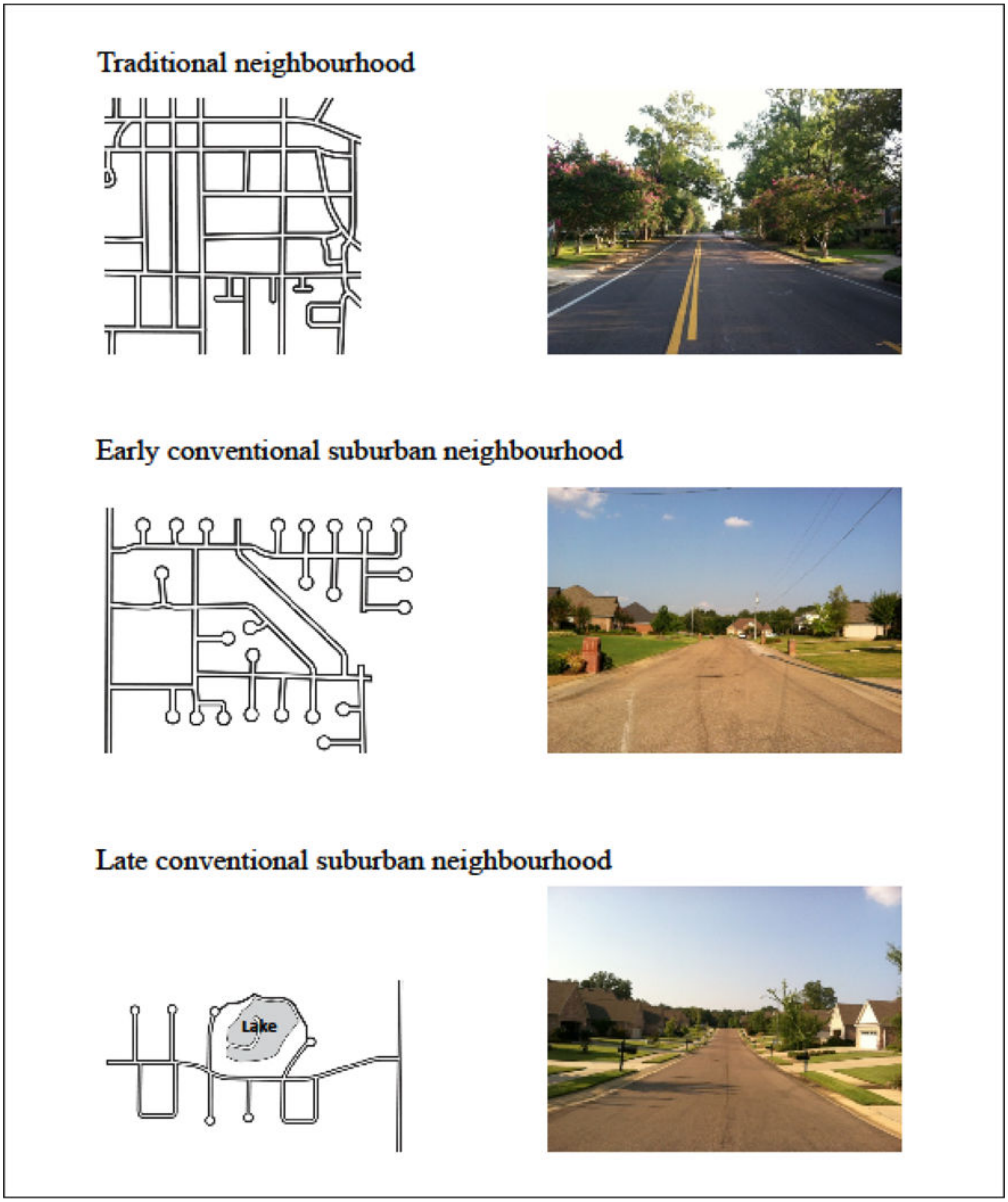

Fig. 3.
Typical street networks and streetscapes in the three types of neighbourhoods.

Table 1.

Neighbourhood objective measurements

	Traditional neighbourhoods			Early conventional suburban neighbourhoods			Late conventional suburban neighbourhoods			Difference
	Greensboro	Overstreet	Total	Greenbriar	Timbercove	Total	Huntington	Country Club	Total	(*p*-value)
Building setbacks (feet)	52.27 (2.06)	43.54 (2.03)	47.20 (1.49)	47.41 (.59)	40.29 (.55)	43.94 (.44)	38.00 (.54)	48.42 (2.27)	41.68 (.99)	.001 **
Lot depth (feet)	213.24 (8.26)	193.68 (6.32)	201.91 (5.08)	181.97 (5.32)	142.16 (1.27)	162.73 (2.97)	147.29 (1.13)	185.23 (8.12)	162.53 (3.73)	<0.001 **
Lot width (feet)	107.27 (5.08)	94.55 (3.25)	99.90 (2.88)	130.39 (1.68)	111.53 (1.17)	121.26 (1.13)	64.41 (2.03)	129.85 (2.59)	89.03 (3.44)	<0.001 **
Lot size (acres)	.52 (.03)	.45 (.03)	.48 (.02)	.54 (.02)	.36 (.00)	.45 (.01)	.22 (.01)	.59 (.03)	.36 (.02)	<0.001 **
Block length (feet)	665.79 (67.25)	650.00 (43.48)	656.61 (17.37)	440.16 (37.83)	602.08 (74.85)	496.29 (15.48)	433.89 (28.05)	1705.00 (116.34)	820.21 (17.10)	.004 *
Street-tree coverage [1]	60.40%	51.20%	55.05%	17.00%	46.00%	27.05%	6.10%	0%	4.25%	/
Street-lighting coverage [2]	200.79	250.71	229.80	316.69	294.90	309.14	260.33	310.00	275.40	/
Front porches [3]	76%	69%	72%	50%	62%	55%	17%	37%	23%	/
Residential density [4]	1.42	2.06	1.74	1.73	2.17	1.88	2.57	1.47	2.12	/
Sidewalk coverage on at least one street side [5]	68%	93%	83%	4%	0%	3%	97%	98%	98%	/
Sidewalk coverage on both street sides [6]	45%	40%	42 %	4%	0%	2%	64%	98%	75%	/
Land-use mix (miles)										/
Distance to nearest institutional destination [7]	.2	.3	.3	1.4	.9	1.2	1.2	.9	1.1	/
Distance to nearest maintenance destination [8]	.6	.4	.5	1.9	1.4	1.7	2.2	2.3	2.2	/
Distance to nearest eating destination [9]	.5	.2	.3	1.5	1.3	1.4	2.1	2.2	2.1	/
Distance to nearest leisure destination [10]	.5	.3	.4	1.9	1.4	1.7	2.2	2.3	2.2	/

Notes:

The number refers to the mean of each variable in its corresponding neighbourhood.

Standard errors are in parentheses.

The difference refers to whether each variable is statistically significant across the three types of neighbourhoods by using one-way ANOVA.

* refers to significance at the $p \leq .01$ level.

** refers to significance at the $p \leq .001$ level.

1. Street-tree coverage is calculated from aerial images as length covered by tree canopy (feet)/total length of streets (feet).

2. Street-lighting coverage is calculated as total length of streets (feet)/number of lighting posts.

3. Front porches is calculated as number of homes with front porches/total number of homes.

4. Residential density refers to the neighbourhood's residential units per acre.

5. Sidewalk coverage on at least one street side is calculated as total length of sidewalks (feet) on at least one street side/total length of streets (feet).

6. Sidewalk coverage on both street sides is calculated as total length of sidewalks (feet) on both street sides/total length of streets (feet).

7. Institutional destinations: bank, church, library, post office.

8. Maintenance destinations: convenience store, grocery store, pharmacy.

9. Eating destinations: bakery, ice cream, pizza, takeout.

10. Leisure destinations: bar, bookstore, health club, theatre, video rental.

Table 2a.

Descriptive statistics of walking behaviours

	All	Traditional neighbourhoods	Early conventional suburban neighbourhoods	Late conventional suburban neighbourhoods	Difference (*p*-value)
Recreational-walking frequency (# days/week)	2.77 (2.26)	2.45 (2.08)	2.87 (2.29)	2.79 (2.34)	0.400
Destination-walking frequency (# days/week)	1.63 (2.43)	1.71 (2.26)	1.63 (2.46)	1.56 (2.52)	0.931
Destination walking (1= yes; 0 = no)	0.40 (0.49)	0.53 (0.50)	0.38 (0.49)	0.33 (0.47)	0.041 *
Number of respondents	289	62	165	62	

Notes:

The number refers to the mean of each variable in its corresponding neighbourhood. Standard errors are in parentheses. The difference refers to whether each variable is statistically significant across the three types of neighbourhoods, byusing the one-way ANOVA.

* $p \leq 0.05$;

** $p \leq 0.01$;

*** $p \leq 0.001$.

Table 2b.

Significance tests and 95% confidence intervals of differences (number of days walking per week) between different types of neighbourhoods

	95% confidence intervals	**Significance test (*t*-score)**
Recreational walking		
Early conventional vs. traditional	0.42 (−0.20, 1.04)	1.32
Late conventional vs. traditional	0.34 (−0.44, 1.12)	0.86
Late conventional vs. early conventional	−0.08 (−0.76, 0.60)	−0.23
Destination walking		
Early conventional vs. traditional	−0.08 (−0.76, 0.60)	−0.23
Late conventional vs. traditional	−0.15 (−0.99, 0.69)	−0.35
Late conventional vs. early conventional	−0.07 (−0.80, 0.66)	−0.19

Note: None of the differences is statistically significant at the $p \leq 0.05$ level.

Table 3.

Descriptive statistics for perceived neighbourhood characteristics

	All	Traditional neighbourhoods	Early conventional suburban neighbourhoods	Late conventional suburban neighbourhoods	Difference (*p*-value)
Accessibility	1.70 (0.89)	2.81 (0.81)	1.39 (0.64)	1.41 (0.66)	<0.001 ***
Convenient access to a store					
Convenient access to a park or a playground					
Good access to public transportation					
Enough park or recreational space in or near the neighbourhood					
Traffic safety	2.70 (0.80)	2.47 (0.59)	2.38 (0.54)	3.77 (0.63)	<0.001 ***
Low amounts of vehicle traffic					
Enough sidewalks					
Well-maintained sidewalks					
Well lighted at night					
Not many street intersections					
Aesthetics	3.23 (0.58)	3.48 (0.50)	3.09 (0.53)	3.34 (0.70)	<0.001 ***
Well-maintained properties					
Many large and mature trees					
Natural features such as lakes, ponds, forests					
A variety of architectural styles					
Interesting things to see					
Social environment	3.76 (0.63)	3.32 (0.59)	3.86 (0.54)	3.96 (0.68)	<0.001 ***
Little or no crime					
Physically active neighbours					
Frequent interaction with neighbours					
Many people walking around					
Number of respondents	289	62	165	62	

Notes:

The number refers to the mean of each variable in its corresponding neighbourhood. Standard errors are in parentheses. The difference refers to whether each variable is statistically significant across the three types of neighbourhoods, using the one-way ANOVA.

* $p \leq 0.05$;

** $p \leq 0.01$;

*** $p \leq 0.001$.

Table 4.

Descriptive statistics for perceived environmental barriers

	All	Traditional neighbourhoods	Early conventional suburban neighbourhoods	Late conventional suburban neighbourhoods	Difference (*p*-value)
Accessibility	2.69 (0.97)	2.70 (0.80)	2.82 (0.99)	2.31 (0.96)	<0.001 ***
Inconvenient access to a store					
Inconvenient access to a park or playground					
No access to public transportation					
No place worth walking to					
Traffic safety	2.37 (0.82)	2.93 (0.87)	2.35 (0.71)	1.87 (0.68)	<0.001 ***
High vehicle traffic					
Poorly maintained sidewalk or no sidewalks					
Not well lighted at night					
Too many street intersections					
No safe route for walking					
Aesthetics	2.15 (0.64)	2.16 (0.53)	2.22 (0.62)	1.96 (0.74)	0.011 *
Poorly maintained properties					
No large trees to provide shade					
Lack of natural landscape features such as lakes, ponds, forests					
Many of the homes look the same					
No interesting things to see					
Small front yards					
Social environment	1.89 (0.65)	2.23 (0.62)	1.83 (0.60)	1.68 (0.66)	<0.001 ***
Crime					
Neighbours are not physically active					
Infrequent interaction with neighbours					
Not many others walking around					
Number of respondents	289	62	165	62	

Note:

The number refers to the mean of each variable in its corresponding neighbourhood(s). Standard errors are in parentheses. The difference refers to whether each variable is statistically significant across the three types of neighbourhoods, using the one-way ANOVA.

* $p \leq 0.05$;

** $p \leq 0.01$;

*** $p \leq 0.001$.

Table 5.

Descriptive statistics for sociodemographic characteristics

	All	Traditional neighbourhoods	Early conventional suburban neighbourhoods	Late conventional suburban neighbourhoods	Difference (*p*-value)
Percent males	42%	45.83%	43.16%	35.21%	0.390
Median age	53.85 (16.81)	47.09 (20.82)	53.70 (14.21)	61.00 (16.09)	<0.001 ***
Employment (employed full time)	49%	48.61%	53.97%	35.21%	0.026 *
Household income ($35,000 or more)	92%	74.60%	95.18%	100%	<0.001 ***
Education (bachelor's degree or higher)	83%	69.44%	89.30%	78.57%	<0.001 ***
Number of respondents	289	62	165	62	

Notes:

The number refers to the mean of each variable in its corresponding neighbourhood. Standard errors are in parentheses. The difference refers to whether each variable is statistically significant across the three types of neighbourhoods, using the one-way ANOVA.

* $p \leq 0.05$;

** $p \leq 0.01$;

*** $p \leq 0.001$.

Table 6.

Results of negative binomial regression models for recreational walking

	All			Traditional		
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Neighbourhood perceptions						
Accessibility	−0.083 (0. 066)	/	−0.083 (0.070)	−0.244 † (0.138)	/	−0.217 (0.167)
Traffic safety	−0.022 (0.070)	/	−0.006 (0.079)	0.034 (0.190)	/	−0.010 (0.194)
Aesthetics	0.270 ** (0.100)	/	0.283 ** (0.107)	0.273 (0.230)	/	0.471 † (0.276)
Social environment	0.117 (0.100)	/	0.069 (0.106)	0.198 (0.197)	/	0.144 (0.248)
Perceived barriers to walking						
Accessibility	/	−0.003 (0.077)	−0.030 (0.080)	/	0.128 (0.168)	0.014 (0.203)
Traffic safety	/	0.063 (0.086)	0.061 (0.092)	/	−0.041 (0.157)	−0.098 (0.153)
Aesthetics	/	−0.004 (0.136)	0.108 (0.144)	/	0.130 (0.283)	0.327 (0.304)
Social environment	/	−0.213 † (0.122)	−0.177 (0.130)	/	−0.147 (0.233)	0.029 (0.275)
Control variables						
Gender	−0.063 (0.110)	−0.042 (0.112)	−0.050 (0.110)	−0.058 (0.233)	0.069 (0.226)	−0.036 (0.242)
Age	0.010 ** (0.004)	0.012 ** (0.004)	0.011 ** (0.004)	0.011 † (0.006)	0.011 † (0.007)	0.010 (0.007)
Income	−0.151 (0.218)	−0.127 (0.221)	−0.167 (0.220)	−0.165 (0.390)	0.081 (0.321)	−0.105 (0.309)
Education	0.009 (0.154)	−0.020 (0.158)	0.014 (0.156)	0.048 (0.264)	0.096 (0.279)	0.126 (0.266)
Employment	0.001 (0.119)	−0.005 (0.122)	−0.002 (0.119)	0.310 (0.241)	0.262 (0.244)	0.271 (0.238)
Constant	−0.536 (0.508)	0.749 † (0.388)	−0.442 (0.648)	−0.727 (0.953)	−0.166 (0.766)	−1.806 (1.506)
Pseudo R^2	0.017	0.012	0.019	0.039	0.021	0.046
Log likelihood	−602.75	−606.32	−601.73	−120.75	−122.93	−119.85
N	289	289	289	62	62	62
Neighbourhood perceptions						
Accessibility	−0.106 (0.114)	/	−0.114 (0.115)	0.122 (0.212)	/	0.069 (0.210)
Traffic safety	0.311 * (0.128)	/	0.411 ** (0.150)	−0.330 (0.210)	/	−0.373 † (0.210)
Aesthetics	0.275 * (0.137)	/	0.264 † (0.143)	0.185 (0.214)	/	0.215 (0.229)
Social environment	0.171 (0.140)	/	0.111 (0.143)	0.177 (0.250)	/	0.202 (0.258)
Perceived barriers to walking						
Accessibility	/	−0.038 (0.102)	0.012 (0.103)	/	−0.136 (0.183)	−0.200 (0.182)
Traffic safety	/	0.038 (0.118)	0.184 (0.128)	/	0.149 (0.242)	0.131 (0.234)
Aesthetics	/	−0.026 (0.193)	0.011 (0.196)	/	−0.137 (0.277)	−0.021 (0.286)
Social environment	/	−0.219 (0.164)	−0.277 † (0.163)	/	0.029 (0.326)	0.127 (0.325)
Control variables						
Gender	−0.151 (0.149)	−0.042 (0.152)	−0.121 (0.149)	−0.075 (0.232)	−0.185 (0.253)	−0.131 (0.251)
Age	0.005 (0.006)	0.005 (0.006)	0.007 (0.006)	0.038 *** (0.010)	0.041 *** (0.010)	0.043 *** (0.011)
Income	−0.054 (0.315)	−0.198 (0.330)	−0.111 (0.320)	/	/	/

	All			Traditional		
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Education	−0.133 (0.226)	−0.124 (0.237)	−0.059 (0.227)	0.393 (0.296)	0.265 (0.333)	0.251 (0.325)
Employment	−0.153 (0.155)	−0.217 (0.159)	−0.152 (0.154)	0.497† (0.275)	0.528† (0.285)	0.636* (0.300)
Constant	−1.088 (0.894)	1.632** (0.599)	−1.145 (1.092)	−2.169† (1.218)	−1.658* (0.807)	−2.289† (1.324)
Pseudo R^2	0.026	0.015	0.032	0.070	0.060	0.076
Log likelihood	−345.57	−349.61	−343.52	−122.98	−124.31	−122.20
N	165	165	165	62	62	62

Notes: The coefficients for logistic regression models are odds coefficients. Standard errors are in parentheses.

†p≤0.10;

$^{*}p$≤0.05;

$^{**}p$≤0.01;

$^{***}p$≤0.001.

The control variable of income is not included in the models for late conventional suburban neighbourhoods. Income is measured as a binary variable (1= \$35,000 and above; 0 = less than \$35,000). All respondents in the late conventional suburban neighbourhoods who answered the income question indicated income above \$35,000.

Table 7.

Results of logistic regression models for destination walking

	All			Traditional		
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Neighbourhood perceptions						
Accessibility	1.302† (0.195)	/	1.368† (0.220)	1.390 (0.511)	/	1.260 (0.594)
Traffic safety	0.941 (0.152)	/	0.971 (0.178)	1.176 (0.570)	/	1.306 (0.703)
Aesthetics	1.504† (0.362)	/	1.418 (0.363)	1.373 (0.822)	/	0.772 (0.583)
Social environment	1.220 (0.272)	/	1.032 (0.248)	1.456 (0.729)	/	1.539 (0.997)
Perceived barriers to walking						
Accessibility	/	1.011 (0.177)	1.067 (0.110)	/	0.918 (0.407)	1.072 (0.603)
Traffic safety	/	1.228 (0.239)	1.092 (0.236)	/	0.706 (0.279)	0.726 (0.302)
Aesthetics	/	0.819 (0.252)	0.975 (0.324)	/	0.508 (0.368)	0.352 (0.300)
Social environment	/	0.655 (0.180)	0.590† (0.179)	/	0.530 (0.315)	0.630 (0.456)
Control variables						
Gender	1.188 (0.303)	1.144 (0.290)	1.177 (0.303)	0.873 (0.523)	0.555 (0.323)	0.610 (0.403)
Age	1.006 (0.009)	1.008 (0.009)	1.008 (0.009)	0.996 (0.016)	1.006 (0.017)	1.001 (0.018)
Income	0.483 (0.239)	0.402† (0.198)	0.425† (0.216)	0.833 (0.645)	0.670 (0.519)	0.722 (0.595)
Education	1.140 (0.412)	1.019 (0.371)	1.117 (0.415)	1.029 (0.662)	0.706 (0.478)	0.626 (0.444)
Employment	1.481 (0.417)	1.456 (0.406)	1.542 (0.440)	0.557 (0.340)	0.721 (0.445)	0.601 (0.393)
Pseudo R^2	0.034	0.023	0.045	0.039	0.104	0.118
Log likelihood	−188.48	−190.53	−186.32	−41.16	−38.38	−37.81
N	289	289	289	62	62	62
Neighbourhood perceptions						
Accessibility	0.943 (0.253)	/	0.964 (0.268)	2.153 (1.370)	/	1.739 (1.223)
Traffic safety	0.774 (0.256)	/	0.897 (0.347)	10.114* (9.201)	/	21.225** (24.143)
Aesthetics	2.451* (0.903)	/	2.481* (0.952)	0.308 (0.225)	/	0.286 (0.244)
Social environment	1.578 (0.523)	/	1.368 (0.475)	0.780 (0.494)	/	0.333 (0.289)
Perceived barriers to walking						
Accessibility	/	1.306 (0.309)	1.232 (0.306)	/	0.258* (0.151)	0.239† (0.177)
Traffic safety	/	1.135 (0.330)	1.063 (0.354)	/	2.569 (1.783)	4.627 (4.338)
Aesthetics	/	0.881 (0.402)	1.215 (0.596)	/	1.012 (0.707)	0.663 (0.563)
Social environment	/	0.469* (0.177)	0.483† (0.194)	/	0.899 (0.712)	0.419 (0.459)
Control variables						
Gender	1.039 (0.386)	1.156 (0.423)	1.016 (0.387)	1.487 (1.018)	1.097 (0.718)	1.036 (0.843)
Age	1.012 (0.015)	1.004 (0.015)	1.013 (0.016)	1.043 (0.032)	1.056† (0.030)	1.079* (0.041)
Income	0.453 (0.351)	0.363 (0.288)	0.398 (0.319)	/	/	/
Education	1.315 (0.771)	1.182 (0.708)	1.375 (0.841)	1.111 (1.013)	0.255 (0.257)	0.297 (0.371)
Employment	1.915 (0.774)	1.706 (0.661)	2.133† (0.890)	2.507 (2.029)	6.082* (5.257)	3.959 (3.879)
Pseudo R^2	0.055	0.041	0.076	0.185	0.122	0.276

	All			Traditional		
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Log likelihood	−103.64	−105.18	−101.42	−32.34	−34.84	−28.72
N	165	165	165	62	62	62

Notes: The coefficients for logistic regression models are odds coefficients. Standard errors are in parentheses.

† p≤0.10;

* *p*≤0.05;

** *p*≤0.01;

*** *p*≤0.001.

The control variable of income is not included in the models for late conventional suburban neighbourhoods. Income is measured as a binary variable (1= $35,000 and above; 0 = less than $35,000). All respondents in late conventional suburban neighbourhoods who answered the income question indicated income above $35,000.