MODELING SATISFACTION WITH THE WALKING ENVIRONMENT: THE CASE OF AN URBAN UNIVERSITY NEIGHBORHOOD IN A DEVELOPING COUNTRY

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ABSTRACT

In light of the numerous benefits of increased walkability, which is commonly defined as the extent to which the built environment encourages conducting walking trips, an increasing number of research efforts have been brought about on the topic by urban planners, transportation engineers, health scientists and many others.

This paper investigates the level of satisfaction of students of the American University of Beirut, Beirut, Lebanon, with the walking environment of the university surroundings. This analysis is conducted by developing two structural equation models for estimating the causal relations between the level of satisfaction with the attributes of the walking environment and the level of satisfaction with the walking environment overall. The first model examines the sample of students who are frequent on-foot commuters, whereas the second model studies the remaining sampled students who typically conduct on-foot trips in the university surroundings for purposes other than commuting (shopping, eating, leisure, etc.).

The resulting models indicate that specific neighborhood attributes have the greatest impact on the level of satisfaction with the walking environment for both samples, these attributes being the ease of pedestrian crossing, sidewalk blockage, cleanliness of sidewalk, vehicular traffic on streets and motorcycles going against traffic on one-way streets. Other attributes, such as the sidewalk width and quality and diversity of activities, are found to have no to little impact on the level of satisfaction of the two samples.

Such findings may contribute to a better understanding of the walking environment in Beirut and aid in future policy interventions.

Keywords: walkability, satisfaction with the walking environment, pedestrians, structural equation modeling.

INTRODUCTION

Walkability, commonly defined as the extent to which the built environment encourages conducting walking trips, is seen as a crucial ingredient to creating more livable communities (*1*). The benefits of walkability are vast, extending from health benefits (*2-5*), to economic (*2,6*), to social and to environmental benefits (*2*). As a result, a growing interest in understanding the influence of attributes of the built environment on walkability has emerged (*7*).

A multitude of studies have investigated the effects of different attributes of the built environment on walkability and identified over 80 such attributes, of which are the ease of pedestrian crossing (*8*), sidewalk conditions (*9*), sidewalk connectivity (*8,10,11*), availability of bus stops (*11*), presence of way-finding aids (*8*) and many others. Furthermore, a number of approaches to measuring such attributes and their impact in terms of walkability have been established. Different indices and models have been proposed, each of which has its strengths and weaknesses. Examples of such indices and models are Walk Score® (*9*), Level of Service (LOS) measures (*12*), Pedestrian Environment Data Scan (PEDS) (*8*), Neighborhood Environment Walkability Scale (NEWS) (*13*) and others.

Given the interest in the subject of walkability, a survey has been conducted within the American University of Beirut in the capital of Lebanon, Beirut, to identify the impact of different attributes of the walking environment on the student population's level of satisfaction with the walking environment. Students are segregated into two categories, those who are frequent on-foot commuters and those who typically conduct on-foot trips for purposes other than commuting; analysis utilizing structural equation modeling is conducted accordingly.

This study has two main contributions to the literature. The first is being one of the first studies capturing local characteristics of pedestrian needs in Lebanon. This study also extends the literature of the yet developing topic of walkability.

The paper is structured as follows. The second section briefly describes the study area. The third section presents a literature review of the concept of walkability and previous studies conducted on the topic. The fourth discusses the data collection process as well as the descriptive findings. In the fifth section, the modeling process is discussed, from exploratory factor analysis to structural equation modeling. The results are as well analyzed in the latter. The sixth section discusses the results and suggests policy interventions accordingly. The final section presents the most important conclusions from this study.

STUDY AREA

The study area targeted in this paper is the neighborhood of the American University of Beirut (AUB). AUB is located in Ras Beirut overviewing the Mediterranean Sea (*14*). To the south of the campus is the Hamra/Ras Beirut region, including two vibrant streets, Bliss and Hamra streets, which contain a rich array of amenities, including restaurants, services, galleries, theatres, etc. (*15,16*). Streets in the neighborhood are local streets serving low-speed traffic.

In terms of walkability, infrastructure is relatively substandard, consisting of low-quality narrow sidewalks with a multitude of obstacles, including but not limited to parking meters, large trash bins, electricity poles, encroachment by construction sites and shops, etc. Consequently, an individual is forced at several instances to cross the road to the sidewalk on the opposite side of the road or even walk on the side of the road rather than on the sidewalk given the poor sidewalk conditions.

FIGURE 1 presents a bird's-eye view of the neighborhood and the streets of interest.

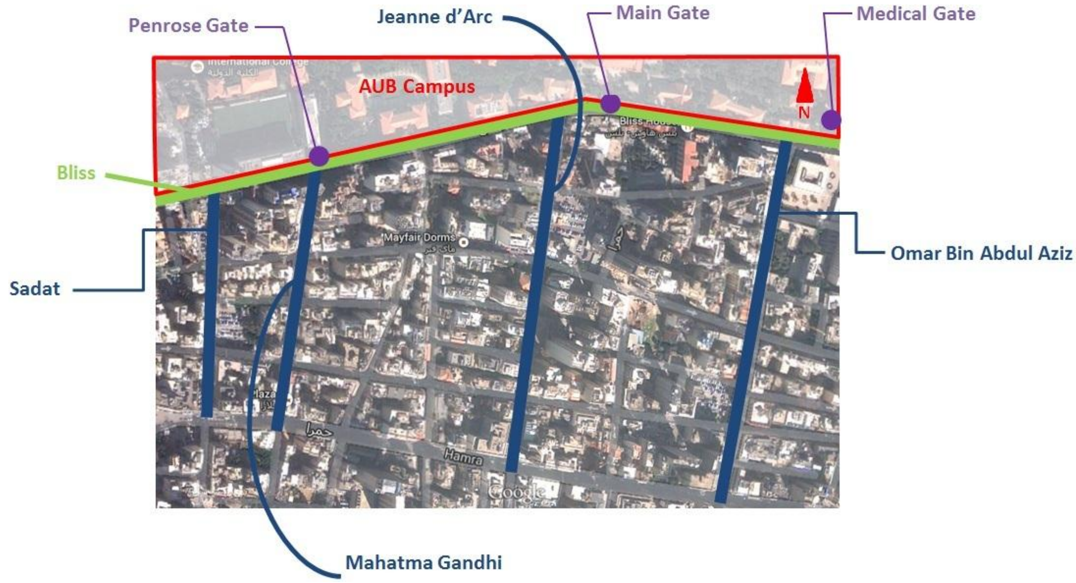


FIGURE 1 Bird's-eye view of the neighborhood under study (17)

The streets investigated in this study, besides the neighborhood as a whole, are: Bliss, Omar Bin Abdul Aziz, Jeanne d'Arc, Mahatma Gandhi and Sadat.

LITERATURE REVIEW

Definition of Walkability

Despite the recent popularity of the concept of *walkability* in urban planning and design fields, the term is rarely found in popular dictionaries and lacks a specific definition. Nonetheless, general and broad definitions recognized by different agencies and authors are available. The New Zealand Transport Agency describes *walkability* simply as "the extent to which the built environment is walking-friendly" (*18*). Another definition is provided by the Mayor of London being "the extent to which walking is readily available […] as a safe, connected, accessible and pleasant activity" (*19*). *Walkability* has also been defined as "[t]he extent to which the built environment is friendly to the presence of people living, shopping, visiting, enjoying or spending time in the area" (*20*).

Noticeably, the three latter definitions are complementary to one another indicating that *walkability* is the extent to which the built environment encourages conducting walking trips. A *walkable* environment should require short distances to reach one's destination and be barrier free, safe, full of pedestrian infrastructure and destinations and upscale, leafy or cosmopolitan (*21*). The latter (upscale, leafy or cosmopolitan) hints at the pedestrian environment being "pleasant for upper middle-class professionals, who have other choices for getting around" (*22*).

Attributes Affecting Walkability

Provided that higher rates of walking are prevalent in highly-walkable areas (*7*), a certain relationship between the walking environment and walkability is expected to exist (*22*). Such a relationship is highlighted by some research and acts as a policy lever for making walking more pleasurable (*9*). Owen et al. indicate that "[t]here is a strong case that substantial and long-lasting environmental and policy initiatives are an important opportunity for making physically active choices easier and more realistic choices" (*4*).

The literature recognizes numerous attributes of the walking environment which have an effect on walkability. Eighty-four of such attributes have been identified and classified under 17 categories as displayed in TABLE 1 on the following page.

Although diverse in nature, a good amount of research has been conducted to date not only to identify which attributes of the walking environment have an effect on walkability, but to what extent. Much of the research aims at identifying certain indices or level of service measures which would enable analysts to easily measure walkability through significant walking-environment attributes.

Weinberger et al. study the power of the readily available Walk Score® model as a cost-effective and transferrable predictor of walkability (*9*). The Walk Score® model assigns scores, on a scale of 100, to neighborhoods by implementing a certain pointing system (refer to (*9*)) to amenities located within a 1-mile buffer (*9*). Furthermore, a distance decay function is utilized in order to give closer amenities a higher value on the point scale (*9*). A penalty of up to 10 points can be implemented based on density of intersections and average block length (*9*). However, the creators of Walk Score® indicate that the score still lacks certain information on “design and safety elements including street characteristics (like sidewalk conditions and speeding traffic), safety from crime, and natural elements like topography” (*9*).

Frank et al., on the other hand, propose an index which utilizes normally available data such as residential density, mixed use, connectivity and retail floor area ratio (*25*). As for level of service (LOS) measures, several have been presented, such as the HCM (Highway Capacity Manual) method, SCI (Sprinkle Consulting, Inc.) LOS, Gainesville Pedestrian LOS, Tan Dandan et al. method and others (*12*). Singh and Jain provide a summary of the latter level of service measures and more.

Other instruments of collecting data on walking-environment attributes and measuring walkability have been presented as well. Clifton et al. developed the PEDS (Pedestrian Environment Data Scan) tool for collecting pedestrian related information falling under four categories: environment, pedestrian facility, road attributes and walking/cycling environment (*8*). Of such information are sidewalk width, sidewalk connections, posted speed limit, degree of enclosure and building setback, slope, etc. (*8*). Another tool, the Neighborhood Environment Walkability Scale (NEWS) and its different versions, assesses “perceived environmental attributes believed to influence physical activity”, such as residential density, infrastructure for walking, neighborhood aesthetics, safety, etc. (*13*), and has been utilized and tested in different regions of the world – including the U.S., Australia and China (*7*,*22*,*26*).

Stevens presents a review of the most significant attempts of measuring walkability preceding the year 2005, including the conceptual frameworks of McMillan and Moudon and Lee as well as the work of Pikora and Colleagues and many others (*1*).

TABLE 1 Categories of Attributes Affecting Walkability and Their Respective Sources

Category \ **Source**	Clifton 2007 (*8*)	Kelly 2011 (*23*)	Reis 2013 (*24*)	Ricci 2011 (*19*)	Singh 2011 (*12*)	Wang 2011 (*10*)	Weinberger 2012 (*9*)	Yin 2013 (*11*)
overall street and sidewalk connectivity	✓		✓		✓	✓	✓	✓
street geometry	✓	✓		✓	✓			✓
street traffic	✓	✓	✓		✓		✓	✓
signal delays					✓			
pavement condition				✓			✓	
sidewalk geometry	✓	✓		✓	✓	✓		✓
sidewalk obstructions	✓		✓	✓	✓			
topography	✓		✓	✓			✓	
urban fabric and landscape	✓			✓	✓			✓
aesthetics	✓	✓		✓	✓	✓		✓
availability and variety of amenities							✓	✓
accessibility and distance to amenities			✓				✓	✓
density and diversity of built environment	✓		✓			✓	✓	✓
availability and proximity of transit	✓		✓				✓	
safety and comfort	✓				✓	✓	✓	✓
population (overall) attributes							✓	✓
trip attributes							✓	

Pedestrian Satisfaction with the Walking Environment

In general, the more walkable an area is, the higher people's satisfaction with walking in that area is, which would lead to a greater extent of walking activity. Therefore, it is important to measure satisfaction and understand how it is influenced by the various factors that determine the walkability of an urban area. Nonetheless, even with the abundance of methods to measure walkability, more direct measures of pedestrian satisfaction with the walking environment are uncommon. Wang et al. indicate that previous studies typically have not considered the "multiple and complex components in which the diverse setting of the environment may influence people's satisfaction" (*10*). According to Zainol et al., "in order to measure walkability, pedestrian level of satisfaction is used [to] evaluate users' perception on the related facilities" (*27*). Furthermore, for instance, Choi et al. indicate the importance of replacing the measure of pedestrian density in the HCM approach for measuring pedestrian level of service with "a more realistic measurement of effectiveness" being the level of pedestrian satisfaction (*28*).

Wang et al. state that walking satisfaction is not only based on the physical attributes of the environment but also on the emotional perception of such attributes. Therefore, their approach in the paper *Exploring Determinants of Pedestrians' Satisfaction with Sidewalk Environments: Case Study in Korea* is to conduct a perception survey targeting emotional response towards different physical attributes (*10*). Wang et al. investigate attributes such as wideness, brightness, openness, tidiness, surface condition, type of land use, etc. (*10*).
By establishing a correlation plot for the research variables versus walking satisfaction as well as a path analysis model, the authors are able to identify which variables have a greater impact on satisfaction. In short, Wang et al. conclude that emotional perception factors have a greater correlation to satisfaction than physical attributes; they note that the correlation between satisfaction and the emotional perception factors representing the physical components indirectly is higher than that between satisfaction and the physical components directly (*10*).

DATA AND DESCRIPTIVE FINDINGS

As part of the Neighborhood Initiative at the American University of Beirut, a survey was launched in November 2013 to collect data on the daily commute of students to and from the university, the potential for switching to a new taxi sharing service, the students' walking patterns in the neighborhood of AUB and their satisfaction with the neighborhood walkability.

The Survey

The survey was web-based and all university students were invited to participate through e-mail. The survey remained active for three weeks within which students were sent two reminders to complete the survey.

Out of 7920 current students (then), 2291 started the survey (28.93% of the student population). Only 1393 students (17.59% of the student population, 60.80% of respondents) completed the survey whereas the remaining 898 only submitted partial responses.

Walkability Questions

The questions targeted in the *walkability* section of the survey are mainly divided into the following categories: questions targeting the walkability at a neighborhood level, questions targeting walkability on Bliss street which borders the university from the southern side, questions targeting walkability on a chosen street – based on which street the respondent uses the most to conduct his or her commute or daily walking trips, respondent's suggested interventions, respondent's level of agreement with given statements regarding walking in the neighborhood of AUB and respondent's on-foot trips on the last day he or she came to AUB.

At the neighborhood level, an initial question inquires about the respondent's satisfaction with the walking environment in the neighborhood of AUB. The respondent is then inquired about his or her satisfaction with attributes of the walking environment – at a neighborhood level – on a 7-point Likert scale ranging from *very dissatisfied* to *very satisfied*. Similarly, at the level of separate streets, whether Bliss street or the chosen street, the respondent is asked to rate his or her satisfaction with given attributes of the walking environment along that street on a 7-point Likert scale ranging from *very dissatisfied* to *very satisfied* as well. The respondent is also asked to rate how bothered he or she is by another set of attributes, also on a 7-point Likert scale which ranges, however, from *not at all* to *very much*. All latter attributes are listed in TABLE 2.

TABLE 2 Attributes of the Walking Environment Inquired about in the Survey

Satisfaction Attributes (neighborhood level)	ease of pedestrian crossing sidewalk blockage cleanliness of the sidewalk vehicular traffic on the streets traffic noise traffic fumes motorcycles going against traffic on one-way streets
Satisfaction Attributes (street level)	sidewalk width sidewalk surface quality and evenness diversity of activities trees and greenery proportion of shadowed sidewalk
Bother Attributes (street level)	buildings with entrance door access to the sidewalk parking access across the sidewalk (to building garage or parking lot) bollards on the sidewalk parking meters on the sidewalk sign posts on the sidewalk cars and motorcycles parked on the sidewalk sidewalk infringement by shops electricity poles on the sidewalk large trash bins

In the section assigned for suggestions and suggested interventions, respondents answer two questions. The first question is to choose from a list of 14 suggested interventions the 3 they believe would improve their walking experience the most. The second is an open-ended question allowing the respondent to type in his or her suggestions.

Several attitudinal statements about walking in the neighborhood of AUB are also presented to the respondent for him or her to indicate their level of agreement on such statements on a 7-point Likert scale. An example of such statements is "I don't mind the absence of greenery as long as the majority of sidewalk is shaded during daytime."

Finally, within the walkability section of the survey, respondents are asked to list the places visited on foot during their last day at AUB – if any – and the time at which these trips were conducted.

Besides the questions included in the walkability section of the survey, respondents are asked about their socio-economic characteristics, including gender, year of university education, major area of study and corresponding faculty, household income and others. Also, all respondents are asked about their satisfaction with their current commute at the beginning of the survey.

Data Cleaning

Given that not all questions in the survey were mandatory in addition to 39.20% of the responses being incomplete, data cleaning is necessary prior to utilizing the data. Note that data from incomplete responses has been used as well – when possible. Accordingly, the data is prepared to take into consideration missing answers. However, the instances of missing answers to questions of concern to this study are few and, therefore, such observations are eventually excluded.

Therefore, out of the 2291 responses (complete and incomplete), 889 (38.8%) include responses to walkability questions. Of the 889 responses, 724 (31.60 % of the 2291 responses) are used in the modeling process.

The cleaned data itself is segregated into two groups: those who commute to AUB on foot (on-foot commuters: OFC) (285 responses out of 724) and those who don't (non-foot commuters: NFC) (439 responses out of 724). Satisfaction with the walking environment is modeled for both groups. Satisfaction with walking on a "chosen street" is assumed to influence satisfaction with the walking environment. The chosen street is the street used for commuting for those who commute to AUB on foot, while for those who don't commute to AUB on foot the chosen street is a street used most of the time for daily non-commute walking trips.

Data Description

Taking the cleaned data as a whole, excluding the 22 observations that did not indicate their gender, the sample consists of 373 female and 329 male students (53.13% and 46.87% of sample, respectively). This distribution between females and males is representative of the AUB student population (52.30% and 47.70%, respectively). Furthermore, the population is also well-represented by the sample in terms of faculties under which students are majoring with the largest deviation from the population being 2.41% for the Suliman Olayan School of Business.

The average household income is 7,680,000 Lebanese Pounds (LBP) per month (or $5,120/month) with a median of 5,000,000LBP/month (or $3,330/month). Respondents are given the choice of not indicating their household income; accordingly, the above value is representative as an average for 53.04% of the sample.

As for the responses to the attitudinal statements, the mean ($\bar{x}$) and standard deviation (s) for each is summarized in the following table.

TABLE 3 Attitudinal Responses Summary

		OFC		NFC	
		$\bar{x}$	s	$\bar{x}$	s
Level of Satisfaction	with walking environment	4.01	1.76	4.06	1.60
	with commute	5.60	1.33	3.95	1.85
Satisfaction Indicators	ease of pedestrian crossing	3.54	1.67	3.71	1.65
	sidewalk blockage	2.67	1.52	2.66	1.48
	cleanliness of the sidewalk	3.18	1.59	3.11	1.58
	vehicular traffic on the streets	2.91	1.45	2.55	1.35
	traffic noise	2.41	1.31	2.35	1.32
	traffic fumes	2.40	1.31	2.30	1.30
	motorcycles going against traffic on one-way streets	1.89	1.25	2.00	1.38

		OFC Bliss		OFC Other		NFC Bliss		NFC Other	
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Satisfaction Indicators	sidewalk width	3.65	1.58	3.06	1.55	3.80	1.69	3.10	1.60
	sidewalk surface quality and evenness	3.63	1.59	3.04	1.57	3.62	1.59	3.19	1.50
	diversity of activities	5.03	1.45	4.26	1.49	5.24	1.43	4.35	1.50
	trees and greenery	3.30	1.76	2.99	1.55	3.47	1.64	3.05	1.44
	proportion of shadowed sidewalk	3.39	1.59	3.37	1.58	3.56	1.41	3.45	1.44
Bother Indicators	buildings with entrance door access to the sidewalk	2.48	1.58	2.72	1.83	2.48	1.64	2.72	1.74
	parking access across the sidewalk	3.49	1.89	3.36	1.87	3.29	1.87	3.17	1.86
	bollards on the sidewalk	3.45	1.88	3.28	1.87	3.32	1.82	3.17	1.82
	parking meters on the sidewalk	3.05	1.85	2.97	1.86	2.89	1.88	2.89	1.84
	sign posts on the sidewalk	2.29	1.52	2.45	1.63	2.29	1.59	2.38	1.68
	cars and motorcycles parked on the sidewalk	2.55	1.65	2.76	1.77	2.54	1.67	2.65	1.71
	sidewalk infringement by shops	5.52	1.84	5.09	2.08	5.45	1.81	5.13	2.01
	electricity poles on the sidewalk	4.14	1.97	3.75	2.07	4.27	1.96	3.88	2.04
	large trash bins	3.27	1.82	3.13	1.91	3.39	1.91	3.36	2.02

By referring to TABLE 3, the average value for the satisfaction with the walking environment is similar for on-foot commuters and non-foot commuters, being 4.01 for on-foot commuters (s = 1.76) and 4.05 for the commuters of other modes (s = 1.60) (on a scale from 1 to 7, 1 being *very dissatisfied*, 4 being *neutral* and 7 being *very satisfied*).

However, on-foot commuters display a higher average level of satisfaction with their commute when compared to commuters of other modes. For on-foot commuters, the average level of satisfaction with the commute is 5.60 (s = 1.33), whereas for commuters of other modes the average is 3.95 (s = 1.85).

As for the indicators, the average ratings are generally close between the two samples, with the largest difference (equal to 0.36) being that of the level of satisfaction with *vehicular traffic on the streets*. The lowest rating is 1.89 in terms of satisfaction with *motorcycles going against traffic on one-way streets*. The highest rating (5.52), on the other hand, belongs to the bother indicator *sidewalk infringement by shops*.

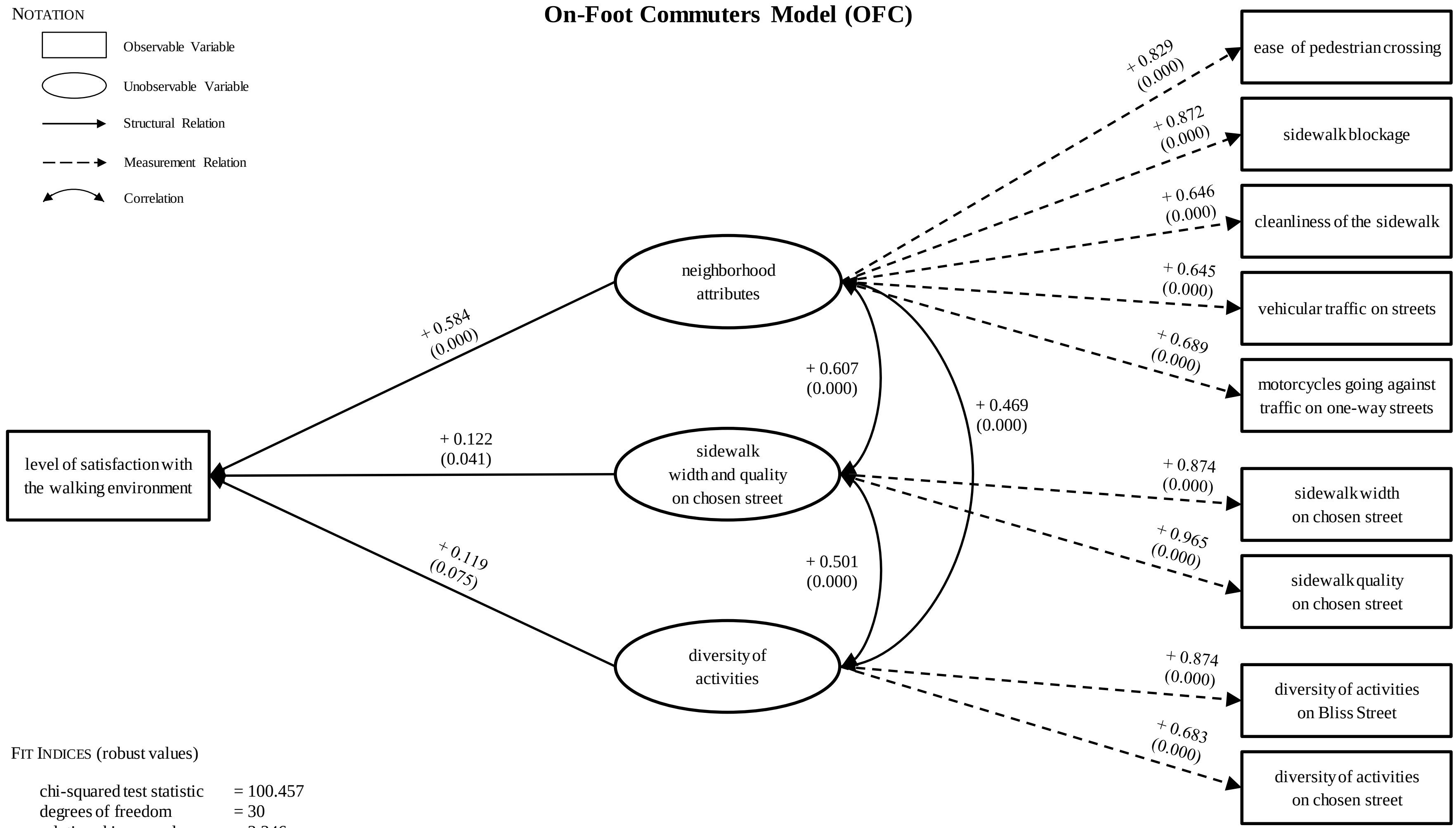
STRUCTURAL EQUATION MODELING

Structural equation modeling (SEM) is utilized for estimating the causal relations between the level of satisfaction with the attributes of the walking environment and the level of satisfaction with the walking environment overall. Two models are estimated, one for the on-foot commuters and one for the non-foot commuters.

Initially, exploratory factor analysis (EFA) is implemented in order to identify the underlying relationships between the variables (attitudinal indicators) and the latent factors. Using EFA results as a base model, the model is further developed through SEM in order to model the level of satisfaction with the walking environment as a function of covariates. SEM is conducted in *R* (version 3.0.3) (*29*) through the package *lavaan* (version 0.5-16) (*30*).

Correlations are allowed between factors and identification is ensured through normalizing the variances of all exogenous latent variables. Furthermore, all observed variables are input into the model as ordinal data in *deviations from the means* form. The estimation method utilized is *diagonally weighted least squares with robust standard errors and mean and variance adjusted test statistic* (*30,31*). The utilization of a robust approach and adjusted test statistics is mainly to accommodate for the non-normality of the data.

The SEM is then improved by removing insignificant factors and variables and running the model again. The process is reiterated until the final model is reached. FIGURE 2 and FIGURE 3 display the two models, for OFC and NFC, with the estimated parameters as well as the respective p-values (between parentheses). Results are also presented in the Appendix in TABLE 4 and TABLE 5.



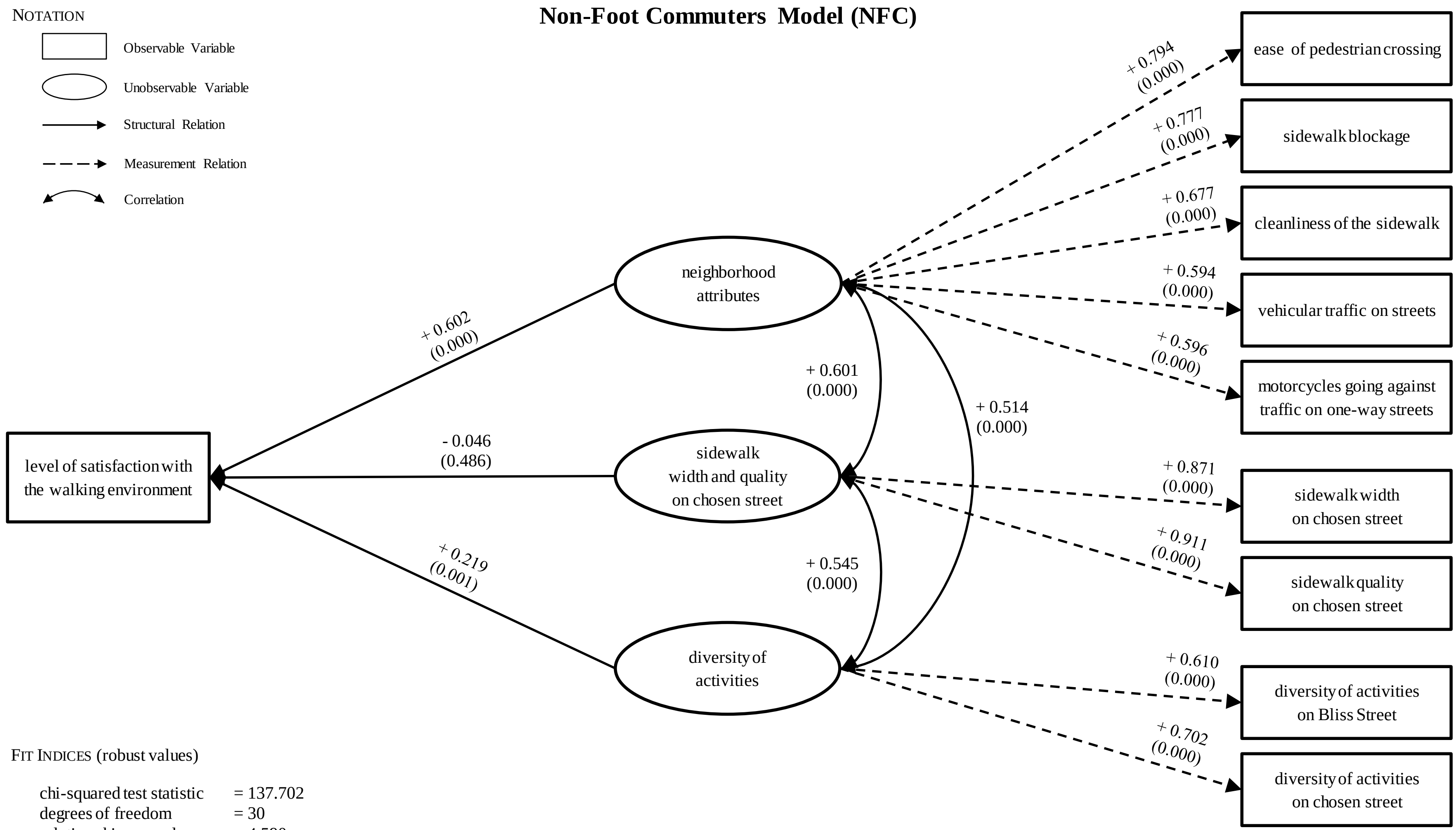
FIT INDICES (robust values)

chi-squared test statistic = 100.457
degrees of freedom = 30
relative chi-squared = 3.346

comparative fit index (CFI) = 0.981
Tucker-Lewis index (TLI) = 0.972

root mean square error of approximation (RMSEA) = 0.091

FIGURE 2 Final structural equation model for on-foot commuters (OFC)



FIT INDICES (robust values)

chi-squared test statistic = 137.702
degrees of freedom = 30
relative chi-squared = 4.590

comparative fit index (CFI) = 0.972
Tucker-Lewis index (TLI) = 0.958

root mean square error of approximation (RMSEA) = 0.091

FIGURE 3 Final structural equation model for non-foot commuters (NFC)

Fit Indices

For a good fit, the ratio between the chi-squared statistic and the degrees of freedom should be less than 5 (*32*); however, Ullman suggests a lower ratio, being less than 2, as an indicator of a good fit (*33*). Here, the chi-squared statistic tests for the null hypothesis that the model fits perfectly in the population (*34*). Furthermore, based on a study by Hu and Bentler, it has been suggested that the RMSEA (Root Mean Square Error of Approximation) be less than 0.06 and CFI (Comparative Fit Index) and TLI (Tucker Lewis Index) be each greater than 0.95 (*34*).

By referring to FIGURE 2 and FIGURE 3, most of the fit indices suggest a good or acceptable fit with the exception of the RMSEA. Both the CFI and TLI values indicate a good fit being greater than 0.95 for each model. As for the relative chi-squared, though Ullman suggests a ratio of 2, the values for the latter two models are acceptable for the relative chi-squared threshold of 5. The RMSEA, however, has a value of 0.09 for both models, greater than the suggested guideline of 0.06.

Analysis

OFC Model Regarding the OFC model, all estimates for the measurement relations are significant at $\alpha = 0.01$, where α is the level of significance. As for the structural equation explaining the level of satisfaction with the walking environment, the latent variables *neighborhood attributes* (coef. = 0.584) and *sidewalk width and quality on chosen street* (coef. = 0.122) are significant at $\alpha = 0.01$ and 0.05 respectively, whereas *diversity of activities* is insignificant at $\alpha = 0.05$. Accordingly, the *level of satisfaction with the walking environment* for on-foot commuters is most influenced by *neighborhood attributes* and *sidewalk width and quality on chosen street*.

Furthermore, the three latent variables are fairly correlated with correlation values varying from 0.469 to 0.607.

Moreover, given that all observed and latent variables reflect satisfaction levels, it is hypothesized that all factors and correlations are positive in value, which is the case as represented by FIGURE 2.

NFC Model Similarly, all estimates for the measurement relations in the NFC model are significant at $\alpha = 0.01$. Unlike the OFC model, the latent variables *neighborhood attributes* (coef. = 0.602) and *diversity of activities* (coef. = 0.219) are significant at $\alpha = 0.01$, whereas *sidewalk width and quality on chosen street* is insignificant at $\alpha = 0.05$. Therefore, the *level of satisfaction with the walking environment* for non-foot commuters is most influenced by *neighborhood attributes* and *diversity of activities*.

Also, the latent variables are fairly correlated with correlation values varying from 0.514 to 0.601.

As in the OFC case, signs are hypothesized to be positive. This is the case for all factors and correlations with the exception of *sidewalk width and quality on chosen street*’s effect on the *level of satisfaction with the walking environment*. However, the latter variable is insignificant and, therefore, its coefficient is statistically equal to zero.

DISCUSSION

Resulting Models

As previously indicated, the SEM models differ in terms of significant latent variables between on-foot commuters and non-foot commuters. In the case of on-foot commuters, their *level of satisfaction with the walking environment* is most influenced by their satisfaction with *neighborhood attributes* and *sidewalk width and quality on chosen street*, whereas in the case of non-foot commuters, their *level of satisfaction with the walking environment* is most influenced by their satisfaction with *neighborhood attributes* and *diversity of activities*.

Given the difference in magnitudes, the *level of satisfaction with the walking environment* is more sensitive to the *neighborhood attributes* than it is to the other significant latent variables (whether for OFC or NFC). This indicates that, regardless of trip purpose, walkers of the neighborhood of AUB are highly sensitive to changes in the general aspects of the walking environment.

The difference between the two models, however, indicates different perspectives based on personal preferences in terms of commute. The models indicate that in the case of people who typically commute on foot (i.e. the case of on-foot commuters), individuals are sensitive to physical aspects of the sidewalk, being the sidewalk width and quality, rather than the diversity of activities along the pathway. However, for those who don't (i.e. the case of non-foot commuters), individuals are insensitive to the latter physical aspects, but are instead more sensitive in terms of satisfaction to the availability and diversity of activities.

The latter observations are sensible as it is hypothesized that frequent on-foot commuters are more concerned with the comfort in conducting their trip which is mostly represented by the *neighborhood attributes* and the *sidewalk quality and width on chosen street*. As for individuals who generally conduct on-foot trips for purposes other than commute (such as for shopping, eating, personal business, etc.), the diversity of activities becomes an important factor. The fact that *sidewalk quality and width on chosen street* has become insignificant can be explained by the reality that walking on sidewalks in Lebanon is an option rather than an obligation; walking on the sides of the road rather than the sidewalk is a norm to avoiding low-quality and narrow sidewalks.

Additionally, a previous version of the model tested for the effect of gender on the *level of satisfaction with the walking environment* through the inclusion of *gender* dummies. Such dummies were later excluded from the model due to their insignificance. It is important to indicate, however, that the students are asked about their day-time trips. Therefore, the two models are representative of trips that are conducted during naturally lit and relatively crowded times of the day; concerns with safety are minimal, which may explain the insignificance of *gender*.

Policy Interventions

Any form of intervention in order to improve the level of satisfaction with the walking environment and, accordingly, walkability needs to target either pedestrians who conduct their trips for commuting purposes (such as reaching AUB), pedestrians conducting day-time trips for other purposes or both at once.

Generally, given the high influence of *neighborhood attributes* on the *level of satisfaction with the walking environment* for both models, it is important to target the underlying factors of the latter latent variable in order to attain the greatest increase in satisfaction for both pedestrian populations. Furthermore, the magnitude of the factor loadings of *neighborhood attributes* on its indicators suggests the extent to which changing these attributes would impact the *level of satisfaction with the walking environment* (even though the causality goes from the latent variables to their indicators, the latent variables can be extracted given the factor loadings; the higher the factor loading, the higher the association between a latent variable and the given indicator). For instance, in the case of OFC, improving the pedestrians' satisfaction with the condition of the sidewalk in terms of sidewalk blockage – intuitively, by decreasing sidewalk blockage – would lead to the greatest impact on their satisfaction with the walking environment whereas in the case of NFC, the highest loading is on the indicator *ease of pedestrian crossing*.

It is important to note, however, that adjusting some factors comes at more ease and lower costs than others. For instance, the *level of satisfaction with the walking environment* can be improved by improving both *ease of pedestrian crossing* and *cleanliness of the sidewalk*. Although improving the *ease of pedestrian crossing* would have a greater overall impact on the *level of satisfaction with the walking environment*, targeting *cleanliness of the sidewalk* would be an easier task and may return better results at lower costs. Such improvement may be achieved through enhanced municipal supervision of the outsourced waste management company responsible for sidewalk cleanliness. Strictly banning motorcycles from driving against traffic – and enforcing this ban – would positively impact walkability at low costs.

Interventions targeting the sidewalk quality or width would impact the satisfaction with the walking environment for students who commute to AUB on foot. Such forms of interventions are essential for enhancing the walking environment and are required in the long-run in order to accommodate increased pedestrian traffic resulting from a more walkable environment. However, given the context of the neighborhood of AUB, which mainly consists of narrow one-way streets and limited right-of-way and faces shortage of parking spaces, it may be too costly and not feasible to widen sidewalks along all street sections in the region. As such, interventions targeting *neighborhood attributes* need to be considered and may have the desired impact. Of such interventions, decreasing *sidewalk blockage*, which has a positive impact on the *level of satisfaction with the walking environment*, is the closest in nature to widening sidewalks by providing a larger effective sidewalk width without changing the overall width.

Interventions targeting the diversity of activities in the neighborhood, on the other hand, would impact the satisfaction with the walking environment for students who do not commute to AUB on foot but rather walk in the neighborhood for other trip purposes. Similarly to the latter, the impact would be small compared to interventions targeting *neighborhood attributes*. Furthermore, increasing diversity of activities in a neighborhood which is already quite diverse in terms of activities is a complex task that is likely to provide only marginal benefits.

CONCLUSION

The topic of *walkability* has been of great interest to transportation and urban planning researchers due to the numerous benefits accrued as a result of increasing the share of trips conducted on foot. Such benefits not only span health benefits, but also social, environmental and economic benefits (2).

This paper studied the level of satisfaction of students with the walking environment in the neighborhood of the American University of Beirut (AUB) in the capital of Lebanon, Beirut. Given the generally poor walking conditions of the neighborhood, including but not limited to poor quality sidewalks and sidewalk infringement by shops, construction sites, large garbage bins and parked vehicles, there is a vital need to identify the most efficient intervention in order to increase people's level of satisfaction with the walking environment, which, in turn, would increase the rate of trips conducted on foot.

Two structural equation models (SEM) have been developed based on data collected through a survey distributed to students of AUB to identify the elements of the walking environment with greatest impacts on the level of satisfaction with the walking environment. The first SEM targets frequent on-foot commuters while the second targets those who typically commute on foot for purposes other than commuting.

The study identified that, for both, the first group and the second, general aspects of the walking environment, being the ease of pedestrian crossing, sidewalk blockage, cleanliness of sidewalk, vehicular traffic on streets and motorcycles going against traffic on one-way streets, have an apparent impact on the level of satisfaction with the walking environment. As for sidewalk width and quality on streets leading to the university, they are mainly of concern to frequent on-foot commuters, while others are more concerned with the diversity of activities along streets serving the neighborhood. Consequently, different policy interventions have been suggested, with the most prominent being the improvement of the general aspects of the walking environment listed above as it has the greatest impact on the level of satisfaction and targets both groups.

All in all, while acknowledging the elevated satisfaction of on-foot commuters with their commute compared to commuters of other modes, their satisfaction with the walking environment is close to neutral, indicating room for improvement. Improvements to the walking environment would not only target the current on-foot commuters, but encourage additional walking trips overall, for on-foot commuters and non-commuters alike. Suggested policy interventions are therefore of great importance and priority.

As for study limitations and extensions, one of the limitations is that some attributes of the walking environment have not been included as part of the study, such as sidewalk connectivity, block length, pedestrian volume, etc. This study is also mainly representative of the perception of young adults (university students) towards the walking environment and only of day-time trips. Furthermore, collected physical data can be added to the modeling process in order to include observed data besides latent in the two models included in this study. Lastly, given current plans by the Municipality of Beirut to upgrade the walking conditions of one of the streets studied in this paper, another extension would be investigating the change in the level of satisfaction with the walking environment and walking patterns in the neighborhood and, specifically, on the upgraded street. The latter extension can be conducted in conjunction with modeling mode switching.

The results of this study can be applied in settings within the city of Beirut similar to the neighborhood of AUB; that is, neighborhoods consisting of local, low-speed, streets which are highly diversified in terms of activities and amenities.

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APPENDIX

TABLE 4 Final structural equation model for on-foot commuters (OFC)

Fit Indices (robust):				
chi-squared test statistic	100.457			
degrees of freedom	30			
relative chi-squared	3.346			
comparative fit index (CFI)	0.981			
Tucker-Lewis Index (TLI)	0.972			
root mean square error of approximation (RMSEA)	0.091			
Latent variables:	Estimate	Std.err	Z-value	P(>|z|)
neighborhood attributes →				
ease of pedestrian crossing	0.829	0.024	34.285	0.000
sidewalk blockage	0.872	0.021	41.801	0.000
cleanliness of the sidewalk	0.646	0.037	17.305	0.000
vehicular traffic on streets	0.645	0.036	17.854	0.000
motorcycles going against traffic on one-way streets	0.689	0.039	17.649	0.000
sidewalk width and quality on chosen street →				
sidewalk width on chosen street	0.874	0.027	32.461	0.000
sidewalk quality on chosen street	0.965	0.025	38.898	0.000
diversity of activities →				
diversity of activities on Bliss Street	0.874	0.048	18.119	0.000
diversity of activities on chosen street	0.683	0.047	14.525	0.000
Regressions:	Estimate	Std.err	Z-value	P(>|z|)
level of satisfaction with the walking environment ←				
neighborhood attributes	0.584	0.058	9.997	0.000
sidewalk width and quality on chosen street	0.122	0.06	2.045	0.041
diversity of activities	0.119	0.067	1.778	0.075
Covariances:	Estimate	Std.err	Z-value	P(>|z|)
neighborhood attributes ↔				
sidewalk width and quality on chosen street	0.607	0.037	16.278	0.000
diversity of activities	0.459	0.053	8.707	0.000
sidewalk width and quality on chosen street ↔				
diversity of activities	0.501	0.047	10.671	0.000

TABLE 5 Final structural equation model for non-foot commuters (NFC)

	Estimate	Std.err	Z-value	P(>|z|)
Fit Indices (robust):				
chi-squared test statistic	137.702			
degrees of freedom	30			
relative chi-squared	4.590			
comparative fit index (CFI)	0.972			
Tucker-Lewis Index (TLI)	0.958			
root mean square error of approximation (RMSEA)	0.091			
Latent variables:	Estimate	Std.err	Z-value	P(>|z|)
neighborhood attributes →				
ease of pedestrian crossing	0.794	0.022	35.537	0.000
sidewalk blockage	0.777	0.023	33.684	0.000
cleanliness of the sidewalk	0.677	0.029	22.961	0.000
vehicular traffic on streets	0.594	0.032	18.553	0.000
motorcycles going against traffic on one-way streets	0.596	0.039	15.246	0.000
sidewalk width and quality on chosen street →				
sidewalk width on chosen street	0.871	0.027	32.220	0.000
sidewalk quality on chosen street	0.911	0.027	34.050	0.000
diversity of activities →				
diversity of activities on Bliss Street	0.610	0.048	12.768	0.000
diversity of activities on chosen street	0.702	0.044	15.914	0.000
Regressions:	Estimate	Std.err	Z-value	P(>|z|)
level of satisfaction with the walking environment ←				
neighborhood attributes	0.602	0.056	10.754	0.000
sidewalk width and quality on chosen street	-0.046	0.066	-0.697	0.486
diversity of activities	0.219	0.064	3.439	0.001
Covariances:	Estimate	Std.err	Z-value	P(>|z|)
neighborhood attributes ↔				
sidewalk width and quality on chosen street	0.601	0.034	17.635	0.000
diversity of activities	0.514	0.050	10.209	0.000
sidewalk width and quality on chosen street ↔				
diversity of activities	0.545	0.046	11.861	0.000

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