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GENDER-SPECIFIC ASSOCIATIONS OF WALKABILITY: LAND USE, WALKING, AND SOCIODEMOGRAPHIC CHARACTERISTICS [1]

ASSOCIAÇÕES GÊNERO-ESPECÍFICAS DA CAMINHABILIDADE: USO DO SOLO, CAMINHADA E CARACTERÍSTICAS SOCIODEMOGRÁFICAS

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ABSTRACT

Walkable spaces have the potential to promote economic vitality, environmental sustainability, and quality of life. Land use mix is one of the most widely studied walkability characteristics, profoundly related to walking. Women have been shown to have more complex travel patterns deeply connected to land use mix adjacent to their household. However, there is a lack of predictive evidence on such a relationship in Brazil. Therefore, the main objective of this study is to empirically verify the influence of land use mix on women's walking behavior, moderated by sociodemographic characteristics in a Brazilian city. With Origin-Destination data from a case study (*Londrina, Paraná*, Brazil), a logistic regression modeling was conducted. Women's travel (n=9670) was the dichotomous response, while sociodemographic characteristics and land use proportions were independent variables. The main results show that land use mix expressively affects women's active travel behavior, where higher employment, income, and educational levels in women seem to negatively determine how much they walk. This study contributes with relevant insights to support evidence-based public policies. In our structurally rigid social paradigm, even further accentuated by our pandemic reality, urban land use policies may play an important role in advancing more gender-sensitive design guidelines.

KEYWORDS: Active travel. Land use mix. Walkable spaces. Women.

RESUMO

Ambientes caminháveis têm o potencial de promover vitalidade econômica, sustentabilidade ambiental e qualidade de vida. A mistura dos usos do solo é uma das características mais amplamente estudadas da caminhabilidade, profundamente relacionada à caminhada. Mulheres apresentam, segundo a literatura, padrões de deslocamento mais complexos, profundamente ligados à mistura de usos do solo adjacente à residência; no entanto, faltam evidências preditivas sobre essa relação no contexto do Brasil. Portanto, o principal objetivo deste trabalho é verificar empiricamente a influência do uso do solo no comportamento de caminhada de mulheres, moderando características sociodemográficas em uma cidade brasileira. Com dados de Origem-Destino de um estudo de caso (Londrina, Paraná, Brasil), foi efetuada uma modelagem de regressão logística. Viagens realizadas por mulheres (n=9670) foram a resposta dicotômica, enquanto características sociodemográficas e proporções de uso da terra foram variáveis independentes. Os principais resultados mostram que o uso misto do solo afeta expressivamente o comportamento ativo das mulheres em viagens a pé, sendo que emprego, maior renda e educação parecem determinar negativamente a sua caminhada. Este estudo contribui com informações relevantes para apoiar políticas públicas baseadas em evidências. Em um cenário de paradigma social estruturalmente rígido, ainda mais acentuado pela realidade pandêmica, as políticas de uso do solo urbano podem desempenhar um papel importante no encaminhamento de diretrizes de design *urbano mais sensíveis a questões de gênero.*

PALAVRAS-CHAVE: *Deslocamento ativo. Uso misto do solo. Espaços caminháveis. Mulheres.*

INTRODUÇÃO

WALKABILITY IS AN urban quality indicator related to how much the built environment encourages or inhibits walking. It has been linked to many individual and environmental benefits, including increased physical activity levels (SALLIS *et al*., 2015) and satisfaction with the environment (LEE *et al*., 2017). In this sense, walkable urban spaces can promote economic vitality and increase the quality of life for residents (GEHL, 2013; SALLIS *et al*., 2016).

Walkability is widely influenced by the compactness of the built environment, which enriches accessibility to destinations within short distances, minimizing possibilities of driving rather than walking (LO; HOUSTON, 2018). Such built environment features are opposite to the tendencies of urban sprawl in contemporary urban development (FRANK *et al*., 2019), offering many sustainability benefits such as the reduction of individual motor-vehicle transportation and subsequent reduction in the emission of hazardous air pollutants (RISSEL, 2009; GILES-CORTI *et al*., 2010).

An array of studies explores active travel behaviors, mainly by foot, establishing causal relationships between land use mix and travel by foot in diverse settings (CHRISTIAN *et al*., 2011; RACHELE *et al*., 2018; SUGIYAMA *et al*., 2019; LEÃO *et al*., 2020). It is understood that more non-residential destinations are present in an area with different land uses, consequently, pedestrian movement is more likely (CERIN *et al*., 2007). The relevance of land use mix is so latent that evidence suggests the possibility that the perceptions of users regarding land use mix may be relatively accurate, even if local residents make more vehicle trips for their daily activities (KOOHSARI *et al*., 2015). Its conceptual origin dates back to the "diversity" proposed by Jane Jacobs (JACOBS, 1961), who argued that the richness of experiences and stimuli in living within a city results from lively urban spaces.

Even though the concept of "diversity" and, therefore, land use mix, are very much connected to the urban quality understood as "Vitality", it is in walkability research that land use mix as a construct is applied more profusely (FRUMKIN *et al*., 2004). Mainly in quantitative approaches, land use mix is conceptualized when measuring the heterogeneity of functionally different uses (LESLIE *et al*., 2007). The literature on land use mix usually considers the concepts of richness and evenness of use, derived from ecological studies (PEET, 1974; MAGURRAN, 1988) .

Evenness indicates the proportion of land uses, representing the extent of variation in the distribution of uses (HAJNA *et al*., 2014), while richness indicates the total quantity of land uses, which point out the possibility of the existence of non-residential uses and seem to be the determining factor to diversity (KRETZER; SABOYA, 2020). Currently, land use mix is most widely quantified (FRANK; ANDRESEN; SCHMID, 2004; GEBEL; BAUMAN; OWEN, 2009; LEE, 2010; GRASSER; TITZE; STRONEGGER, 2016) through a variation

of the equations of Shannon's entropy, a measure of the evenness of uses, representing the extent of the variation in the distribution of land uses (HAJNA *et al*., 2014).

However, the possibility of existence of non-residential land uses seems to be the determining factor to land use diversity (KRETZER; SABOYA, 2020). Therefore, studies indicate simpler metrics as being as coherent in the objective measurement of land use mix, such as the proportion between residential uses and other types of destinations, obtained from simpler and more readily available information (SONG; MERLIN; RODRIGUEZ, 2013; SUNG; LEE; CHEON, 2015). By underlining such quantitative discussions, it can be understood that increasing equity in urban environments is essential for the promotion of social diversity with access to such walkable and compact infrastructure (FAGAN; TRUDEAU, 2014).

Urban theorists have long hypothesized that urban sprawl, marked by a low land use mix, reinforces a large array of gender[2] disparities, including walking behavior (HANDY, 2004). Initially, walking differs between men and women mainly as the female participation in the job market increases (CRANE, 2007). Women have been known to make more trips for shopping for food or domestic chores and less leisure trips (POLLARD; WAGNILD, 2017). In the same sense, the understanding that women have more complex travel patterns and are more likely to engage in trip chaining, from non-work to work trips, is widely and historically recognized (McGUCKIN; MURAKAMI, 1999; SCHWANEN; KWAN; REN, 2008; BROWN; SMITH, 2016; LO; HOUSTON, 2018). Thus, it can be inferred that women's walking is considerably influenced by land use mix, where living in more diverse environments will probably promote greater walking opportunities than living in areas without non-residential uses.

Despite the large volume of current research on walking and plentifulness of available evidence, the study of gender in walking remains limited. Especially in walkability research and its components, such as land use mix (OWEN *et al*., 2004), gender is rarely deeply investigated. The limited scholarly attention to women's experience as pedestrians indicates a research gap in understanding women's transportation patterns (GOLAN *et al*., 2019). The existing literature that focuses on analyzing such patterns in the context of urban characteristics generally points to substantial disparities between men and women, including their perception of attributes of the urban landscape (CLIFTON; LIVI; PARK, 2005), fear of crime (PAIN, 1997; KOSKELA; PAIN, 2000), and influence of land use patterns over their walking levels (CLIFTON; LIVI; PARK, 2005).

The research gap related to the influence of physical elements on women's specific active behaviors is even more latent in countries ranked between low and middle income, such as Brazil (ADLAKHA; PARRA, 2020). In such contexts, active travel promotion is paramount due to the rapid expressive increase in population (BOUTAYEB; BOUTAYEB, 2005) and deep social disparities. In the same sense, researchers have long pointed out that existing evidence lacks

sociodemographic moderations (DYCK *et al*., 2015), such as the effect of individuals' income, since the labor division within families is determined, in part, by their income earning potential.

Considering all methodological and conceptual needs presented above and the latent research gap on gender differences within walkability analysis, the main objective of this study is to empirically verify the influence of land use mix on women's walking behavior, moderated by sociodemographic characteristics in a Brazilian city. To do so, logistic regression modeling was conducted, considering women's walking trips, income, employment status, age, educational attainment, and land use patterns of their zone of residence.

Only from this broader consideration of moderating characteristics on the relationship between walking behaviors and the built environment will it be possible to document the effects of land use mix on travel considering gender differences (BOARNET; HSU, 2015). In our structurally rigid social paradigm, urban land use policies may play an important role in forwarding more gender-sensitive land use policies and design guidelines. On a more urgent note, considering pandemics like COVID-19, land use policies promoting dense mixed-use neighborhoods can contribute to the reduction of both non-communicable diseases and infectious diseases, equitably creating activity-friendly communities (ADLAKHA; SALLIS, 2020).

METHODOLOGICAL PROCEDURES

Considering the phenomenon of the influence of land use characteristics in women walking as contemporary and contextual, hence, inseparable from reality, the ideal research strategy is the Case Study (YIN, 2001). The city of *Londrina* (*Paraná*, Brazil) was selected as a case, mainly due to the availability of current and precise data. In 2020, the *Instituto de Pesquisa e Planejamento Urbano de Londrina* (IPPUL) (INSTITUTO DE PESQUISA E PLANEJAMENTO URBANO DE LONDRINA, 2019), conducted an Origin and Destination (OD) research to prepare its Mobility Plan, in compliance with the Federal Law nº12587. Such raw data is available at the website of the city of Londrina (http://ippul.londrina.pr.gov.br/index.php/plano-de-mobilidade.html) and was systematized in a Geographic Information System environment (ESRI ArcMap 10.6) by the authors.

The OD survey was conducted with a sample of 5,131 households, totaling *n*=13779 individuals, both men and women (n is the number of individuals who compose the sample of the *N* – total population). This data is aggregated in the 91 city zones within the municipal limits, however, only 84 of these zones are contained in the urban perimeter and were considered (*Figure 1*). The seven zones excluded present rural characteristics that are not contemplated by this research's theoretical and analytical bases.

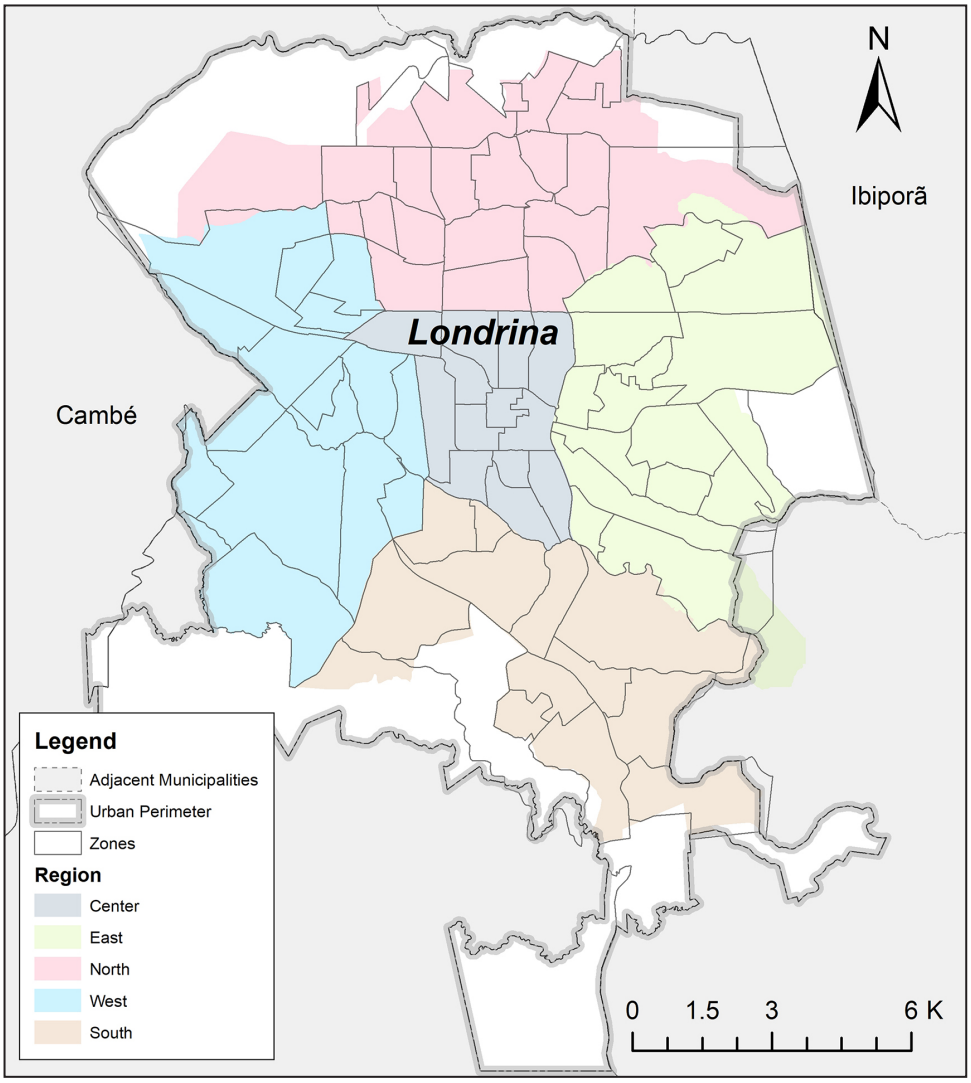

FIGURE 1 – Zones and regions in the city of *Londrina*, PR. Brazil.

Source: Elaborated by the authors (2020), based on *Instituto de Pesquisa e Planejamento Urbano de Londrina* (2019).

SOCIODEMOGRAPHIC VARIABLES

The OD survey questionnaires were applied to all residents of the 5,131 households aged ten or more. Sociodemographic information on individuals and trips made on the weekday prior to the interview were obtained. Gender, age, education, employment, and overall family income information were considered for this research. Such moderating variables were selected in consonance with the walkability and active travel literature, which indicates these as some of the most heavily influential variables to walking levels (CAUWENBERG *et al.*, 2011; DYCK *et al.*, 2015; LUAN; RAMSAY; FULLER, 2019).

The trips conducted by all respondents, motorized or non-motorized (on foot, by car, motorcycle, taxi, bus, apps, *etc.*), were also collected and totaled n=19323. However, when it comes to gender, from this total, only n=9670 trips were conducted by women. Considering the interest of precisely exploring the transport behavior of women in this study, this was adopted as the total study sample.

Descriptive statistics on the total number of trips and the trips conducted by women are available in *Table 1*. Important points to be highlighted are the differences in the composition of household income and employment,

that decrease in the trips conducted by women in comparison with the total number of trips, which could be considered an initial indication of the possible social disparities women face. The unbalancing of categories must be recognized in the Age and education variables, which might affect results.

TABLE 1 – Descriptive statistics on sociodemographic distributions of the trips conducted by all respondents (n=19323), motorized or non-motorized and by women (n=9670).

Sociodemographic Variables	Total number of trips (n=19323)	Percentage of the total number of trips (n=19323)	Total number of trips conducted by women (n=9670)	Percentage of the total number of trips conducted by women (n=9670)
Gender				
Female	9670	50.05	—	—
Male	9653	49.95	—	—
Modality				
Walking	4371	22.62	2519	26.05
Other	14952	77.38	7151	73.95
Age				
Child (≤12)	2300	11.90	1095	11.32
Adult (<13 to 59<)	13980	72.35	7012	72.51
Older adult (≤60)	3043	15.75	1563	16.16
Household income				
≤ 2 MS	9281	40.03	4904	50.71
<2 to 5 MS<	10042	51.97	4766	49.29
Education				
Illiterate	2167	11.21	1134	11.73
Elementary and middle school	5805	30.05	2947	30.42
High School/University	11351	58.74	5589	57.74
Employment				
Unemployed	8545	44.22	4950	51.19
Employed	10778	55.78	4720	48.81

Source: Elaborated by the authors (2020), based on *Instituto de Pesquisa e Planejamento Urbano de Londrina* (2019).

LAND USE MIX

Quantifying the mix of uses present in an area has been simply put as proportions between uses since the seminal study proposed by Cervero and Kockelman (1997). Such proportion measures may allow for the quantification of the relative presence between different land use types. Proportions are easily computed and offer effective information on land use intensity within an area, having the potential to yield meaningful results (SONG; MERLIN; RODRIGUEZ, 2013).

Considering such methodological evidence, the proportion of non-residential land uses in relation to the total number of occupied parcels was considered a representation of land use mix. Further, the proportion of residential uses in relation to the total number of parcels was considered as a representation of the lack of presence of alternative destinations (*Figure 2*). Data for such calculations was provided by the IPPUL, a public agency in the city of *Londrina*, in 2019 and was systematized on the ESRI ArcMap software, version 10.6, by the authors.

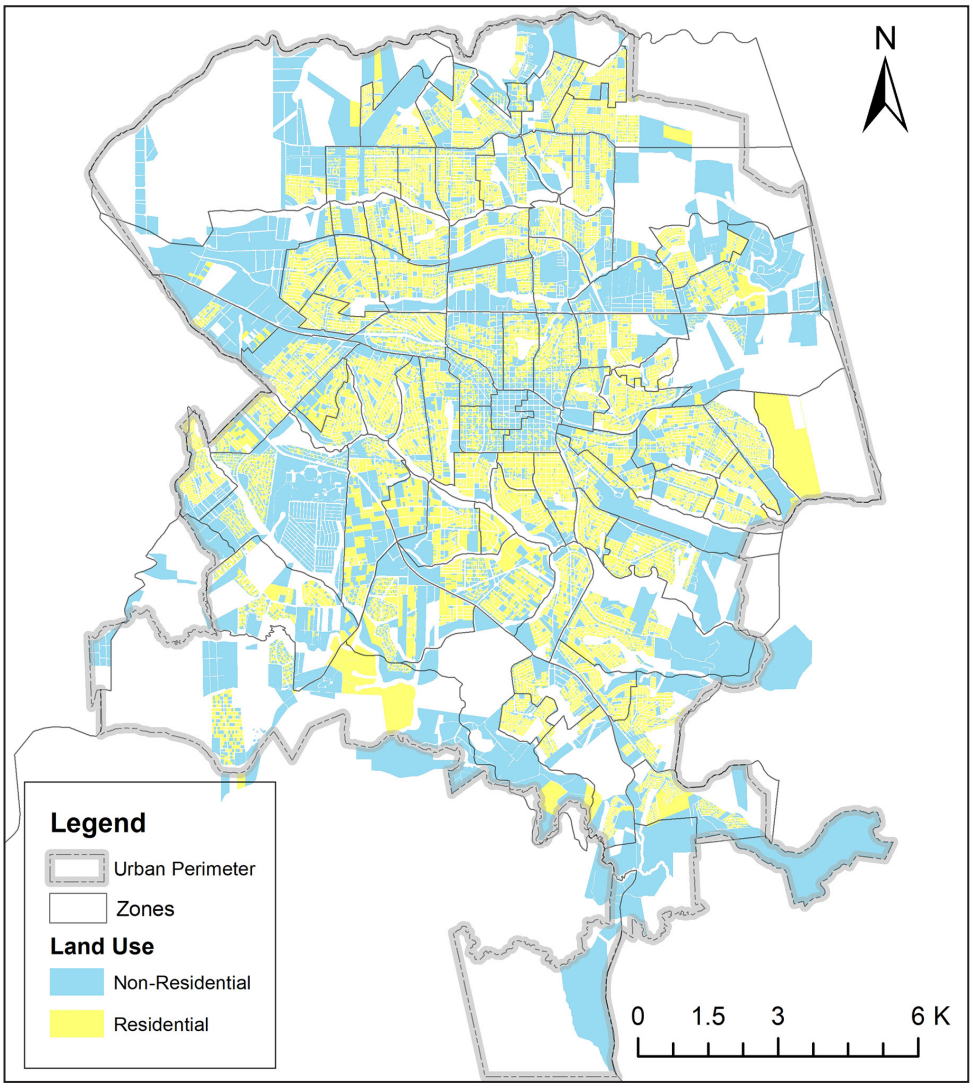

FIGURE 2 – Land uses: residential and non-residential categories in the city of *Londrina*, PR, Brazil.

Source: Elaborated by the authors (2020), based on *Instituto de Pesquisa e Planejamento Urbano de Londrina* (2019).

MODELING: LOGISTIC REGRESSION

To unveil the influence of land use mix on women's walking behavior, considering the moderating effects of sociodemographic variables, a Logistic Regression analysis was conducted. In such modeling, a dichotomous response variable is understood through independent variables that influence such outcome (HOSMER; LEMESHOW, 1989). Trips conducted by women were adopted as a dependent variable, categorized binarily in relation to their modal (by foot: yes or no), sociodemographic characteristics (age, education, employment, family income), and land use mix metrics (proportion of non-residential land uses and proportion of residential uses per zone) were the independent variables. All independent variables were categorized considering their natural breaks (NORTH, 2009).

For Logistic Regression, the adjustment between the independent variables is taken into account, considering the confusion effects between them (HOSMER; LEMESHOW, 1989). The risk of the outcome happening, in this case, a woman walking, can be expressed by the estimator, called *Odds Ratio* (OR) (THOMPSON; MYERS; KRIEBEL, 1998). Through OR, it is possible to verify the ratio of odds that an event will happen in opposition to it not happening under the same circumstances. In this case, the estimator assesses the chance of an individual falling into a category of the independent variables, having a woman walking, our condition of interest, compared to a woman not walking. If the OR is greater than one, it can be interpreted that the respondent variable of walking is more likely to happen when the characteristic represented also exists. On the other hand, if the OR is below one, there is a negative association and a reduction of chances of the outcome happening in the presence of that explanatory variable (AGRESTI, 2007).

The steps taken for the conduction of such analysis started with the selection of candidate variables for a multiple regression model through univariate logistic regression analysis of each covariate with the outcome. The parameters for inclusion in the following multivariate model included those with a p-value inferior to 0.05 (5%) in the maximum likelihood estimator obtained using the Fisher score method. In sequence, a multiple logistic regression was constructed, introducing the significant independent variables one by one. A final model was obtained containing significant covariates at the 5% significance level, where crude and adjusted OR were, with 95% confidence intervals (CI95%). The risk and protectiveness of independent variables were interpreted based on the theoretical implications of the Adjusted OR. All procedures described above were conducted using the R statistical software (R CORE TEAM, 2020).

RESULTS AND DISCUSSIONS

The results of Multiple Logistic Regression analysis (*Table 2*) indicates that for every walking trip conducted by women of lower-income levels (two minimum salaries or less), the OR of their higher-income counterparts are much lower

for the two consecutive higher income categories (OR=0.69 and OR=0.43, respectively). These results align with the literature that indicates that lower-income individuals of all genders present higher levels of active travel for their own locomotion (AUGUSTO *et al*., 2017). Such a scenario is widespread in low and middle-income countries where social disparities are abrupt. Further, evidence indicates that, in such contexts, motor vehicle ownership rates decrease for women in lower-income groups (ADLAKHA; PARRA, 2020), impacting their transportation options.

TABLE 2 – Univariate and multiple Logistic Regression analysis, considering the walking habits of women as an outcome.

Variable	Crude OR	CI95%	*Adjusted OR*	CI 95%	p-value**
Income					
≤ 2 MS	1.00*	–	–	–	0.001
<2 to 5 MS<	0.61	(0.55,0.67)	0.69	0.62,0.76	
≤ 5 MS	0.33	(0.28,0.4)	0.43	0.36,0.51	
Age					
Older adult (≤60)	1.00*	–	–	–	
Adult (<13 to 59<)	1.48	(1.31,1.67)	1.02	0.9,1.17	
Child (≤12)	2.57	(2.25,2.93)	1.63	1.41,1.88	0.001
Education					
Illiterate	1.00*	–	–	–	
Elementary and middle school	0.98	(0.85,1.14)	1.10	0.94,1.28	
High School / University	0.6	(0.52,0.69)	0.79	0.68,0.92	0.001
Employment					
Unemployed	1.00*	–	–	–	
Employed	0.35	(0.32,0.39)	0.42	0.38,0.47	0.001
Proportion of non-residential uses					
Low	1.00*	–	–	–	
High	2.4	(1.65,3.49)	2.38	1.57,3.61	0.001
Proportion of residential uses					
Low	1.00*	–	–	–	
High Note:	0.77	(0.67,0.89)	0.77	0.66,0.91	0.002

Note: *=1.00: reference category; CI 95%: 95% Confidence Interval; ** α=0.05 significance level; MS: Minimum Wage.

Source: Elaborated by the authors (2020), based on *Instituto de Pesquisa e Planejamento Urbano de Londrina* (2019).

In parallel, the adjusted *Odds Ratio* for education indicates that women with higher educational levels have a much lower tendency to walk, opposing to poorly educated or illiterate women. The general literature on the moderation effects of educational attainment in walking reports mixed results, indicating stronger associations in less-educated adults (FORSYTH *et al*., 2009) and possibly more walking in individuals with higher educational levels (OWEN *et al*., 2007). However, it can be conjectured that in lower and middle-income countries such as Brazil, where educational attainment is historically dependent on social status, the evidence obtained here is relevant in enlightening such paradigm, specifically for women that are, moreover, associated with less car usage than men (VANCE; BUCHHEIM; BROCKFELD, 2004).

When it comes to age, adult women (OR=1.02) and children (OR=1.63) have shown to have a higher tendency to walk over older women. It can be conjectured that active behaviors decrease with age due to lack of available quality infrastructure, increasing the functional limitations of the elderly (RANTAKOKKO *et al*., 2010). This is in line with evidence from the literature that indicates a decrease in walking levels in higher ages (CAUWENBERG *et al*., 2012). Considering population aging tendencies, active travel may play an essential role in preventing chronic diseases and cognitive decline in older women (WEUVE *et al*., 2004) and a consequent decrease of the burden on public health (CAUWENBERG *et al*., 2011). Considering this scenario, walking should be encouraged through the provision of quality-built environment features.

It must be noticed that the difference between older women and adult women in walking, when interpreting an adjusted OR, is not too discrepant. This can be construed as a social phenomenon of the reality of a low-income country, where government provisions of solid social providence policies that may enable the elderly to retire promptly are compromised, maintaining their need to work and travel. In relation to the results on younger women walking, they seem to be contrary to evidence from the literature that indicates lower levels of activity among young girls (BUCK *et al*., 2014). It can be conjectured that, in low-income countries such as Brazil, women still play a determinant role in family dynamics, being attributed large responsibilities from younger ages.

The employment status explainable variable, binary by nature, presents results indicating that employed women have a much lesser chance (OR=0.35) of walking than unemployed women. This reinforces the research evidence that transportation behavior is largely determined by an individual's financial status (BOARNET; HSU, 2015). It can be highlighted that household and child-oriented responsibilities are constant key factors, even with the increased participation of women in the job market (CRANE, 2007). The obtained results are parallel to those for the income and education variables, indicating that a relatively higher female job market participation, higher educational levels, and a consequently higher earning potential are linked to less walking behaviors, a reflection of social and economic structural difference between genders and

within genders when it comes to transportation. Women are more prone to do more food and grocery shopping, child serving, and household errand trips comparable men (POLLARD; WAGNILD, 2017), and, if they are employed there are greater chances that these trips will be conducted by car.

Considering that the base level of housework for women is much higher, even if a woman makes more money than her spouse (BITTMAN *et al*., 2015), it can be inferred that her possibilities of transportation choices are limited due to time management. Further, women are understood to suffer significantly larger stress levels than men when walking in public places. Such factors may also contribute to the option not to walk when the income available allows for such. However, consequently, walking for leisure is also significantly below recommendations (ADLAKHA; PARRA, 2020). In conjunction with the fear promoted by social conditions and public space design, a spatial expression of the patriarchy, that imposes notions on women's roles and appropriate places (PAIN, 2001), walking is a generally suppressed behavior among women, being avoided when income, education, and employment status allow for other opportunities.

Contextualizing such results in the city of *Londrina* (Brazil), it can be initially discussed that demographically, its population surpasses the 500,000 mark. It is composed mainly of women (263,628 women or 52% of the city residents). The fact that the female population makes up the majority needs to be emphasized, making the results found in this research even more tangible. Further, it must be considered that, from this percentage of women, 7.1% are over 60 years old, a fair part of the population that, according to the results obtained here, walks less than other age groups and needs policies and incentives to increase walking behaviors (INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA, 2010).

As for income, structural social disparities compose the city of *Londrina*, where the poorer 80% concentrate 42.77% of the municipality's income, while the richer 20% concentrate 57.23%, according to the *Instituto Brasileiro de Geografia e Estatística* (2010). Considering these data, this research's results and the evidences in literature, lower-income women walk more; however, they are more susceptible to health issues and lower leisure walking than higher-income women who walk less in general. Thus, despite both income categories being deeply separated by our social paradigm, in this case study, it is clear that all groups of women need more attention for increased walking behaviors, being through infrastructure or social incentives.

When it comes to built environment characteristics, land use mix was represented here as the proportion of non-residential uses on the individuals' housing zone. OR indicated that women residing in areas with a high proportion of non-residential uses, therefore with greater availability of destinations, have a 2.4 greater chance of walking than women residing in areas with a low proportion of non-residential uses. This is an indication

of the possible strong relationship between women walking and the land use composition around their household. On the other hand, for the proportion of residential uses on present on the individuals' housing zone, OR indicate that, for each walking trip conducted by a woman living in an environment with low proportions of residential uses environment, 0.77 are conducted by women residing in places with a high proportion of residential uses. These results also indicate that the prevalence of residential uses, and the consequent lack of diversity between different use categories, might be detrimental to women's walking behavior.

The question as to whether land use patterns influence women's walking behavior in Brazil is enlightened by the obtained results, indicating that more compact communities seem to provide opportunities for walking. However, in terms of gender equality, women have historically been understood to engage in fixed activities more frequently than men (PICKUP, 1988), hindering transportation freedom to consider more sustainability-friendly modes such as walking (SCHWANEN; KWAN; REN, 2008). Such concept is expressed in the results obtained, where more educated women with jobs and higher income seem to generally walk less. In such a structurally rigid social paradigm, urban land use occupation policies may positively contribute to design guidelines encouraging denser occupation through more gender-sensitive land use policies.

Solid literature evidences indicate that activity rates are higher in areas with greater land use mix (FRANK; ANDRESEN; SCHMID, 2004; EWING *et al*., 2014). However, in a paradigm that exposes patriarchal power mechanisms to women in the attribution of greater responsibility for domestic labor despite their participation in the labor market (SCHWANEN; KWAN; REN, 2008), it seems to be relevant that urban design policies consider providing opportunities for greater within-household gender equality through the provision of destination options within walking reach, so that populations such as those of working women might have more destinations worth walking to, so that these women may get more exercise (LO; HOUSTON, 2018)

The literature indicates that, in high-income countries, walkability and land use mix establish a clear link to real estate prices, connected to more developed areas (PIVO; FISHER, 2006). In Brazil, there is no record of specific research on this topic. It can be conjectured that high-income women possibly live in areas with less land use mix, a reflection of traditional Brazilian occupation patterns, where large areas of single-use vertical residential buildings or large horizontal private condominiums are directed to higher-income classes. However, further evidence is needed to establish clear causal trends.

FINAL CONSIDERATIONS

A binary multilevel logistic regression analysis in a representative case study with an up-to-date database reveals evidence of a trend that the walking

behavior of women is sensitive to land use occupation and sociodemographic differences, especially related to income, as suggested in previous studies. The evidence obtained in this study indicates that, in line with the literature, land use mix affects women's active travel behavior. Further, higher income and education – directly related to employment – seem to be expressive characteristics in negatively determining their walking behavior. These are indications that working women that are more spatially and temporally constrained due to household and childcare activities have a reduction in freedom to explore urban opportunities and transportation options. Urban design heavily contributes to such burdens. However, it possesses the power to ameliorate them by providing safe and accessible alternatives, as is active travel.

The analysis conducted here proposes several significant contributions. First, this study adds to the debate of the growing Brazilian scientific literature on the objective quantification of walkability, here specifically of land use characteristics – a proxy for walkable environments – moderated by gender discussions and socioeconomic characteristics. Although relevant to support evidence-based public policies and scientific-academic research, it can be pointed out that, in a context marked by a socio-political framework of patriarchal relations, from social vulnerability to structural income disparities, political actions for environmental improvements aimed at walking women should always consider such intangible barriers. Furthermore, the obtained evidence must be taken with critical consideration of our social urban scenario, marked by structural crime, insecurity, and a persistent lack of infrastructure and maintenance. Thus, our results must be considered in the context of the general issues of public spaces for pedestrians in Brazilian cities.

Other limitations include the variety of land use measures applied. Such research field is under intense methodological changes and still relies on inconclusive findings regarding the ideal measure for land use mix quantification. Understanding representations and varying compositions of land use classifications and their impact on walking behaviors, including gender differences, remains uncertain. Future studies can further contribute to such research efforts.

For the present study, such data was not available. However, it is paramount that future studies control the sociodemographics of race when studying gendered walkability[3]. The existence of spatial differences structured within gender, especially concerning race, income, and age, should not be overlooked. The relationship between women and public spaces, including their fear, is shaped by their identity. Therefore, considering it to be uniform is not ideal. Evidence is also needed on gender differences in general walkability, comparatively.

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NOTES

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2. This paper uses the term gender in reference to biological sex differences, as is traditional. However, an extensive body of research explores the "social construction of gender" (LORBER; FARRELL, 1991).
3. Term adopted according to the recent research proposed by Golan *et al*. (2019).

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