Australasian Transport Research Forum 2021 Proceedings
8-10 December, Brisbane, Australia
Publication website: http://www.atrf.info

Influence of walking accessibility on older people walking preference

Kaniz Fatima[1], Sara Moridpour[2]

[1]PhD researcher, Civil and Infrastructure Engineering Discipline, School of Engineering, RMIT University, Melbourne, Australia

[2]Associate Professor, Civil and Infrastructure Engineering Discipline, School of Engineering, RMIT University, Melbourne, Australia

Email for correspondence: kaniz.fatima@rmit.edu.au

Abstract

Travel behaviour models are necessary to identify travel demand and planning transport systems. Many studies identify various approaches to measure walking accessibility and travel behaviour modelling. However, a limited model is developed to analyse the older peoples' walking as a transport mode preference based on travel time, population, street connectivity and spatial area. This study presented a Binary logistic regression model to observe the older commuters' transport mode preference. This research examines four major travelled destination types (shopping centres, health care centres, education centres and recreational centres) for the elderly. The framework of this study comprises four parts. Firstly, the study develops a walking accessibility index for older commuters to observe the access level. Afterwards, several numbers of the various binary model (BL) are evaluated and compared. The binary models are developed using older commuters' walking accessibility index, socio-economic (gender, relation, car license, car numbers, income, disable parking permit, dwelling type, dwell ownership), and built-in environmental (home sub-region, land mix use) variables. Then two BL model is proposed after model validation. Finally, the best fit model is validated using statistical methods (Omnibus test, Hosmer and Lemeshow test). Moreover, the probabilities of selecting walking as a transport mode by older travellers are analysed by statistical model and compare with actual travel survey datasets. The results confirm that the proposed time-based walking model can describe the older commuters' walk related travel decisions. The proposed walking accessibility index and the preference model can be helpful to plan distributions of essential destinations coverage. Future urban and policy planners can use the walking preference to evaluate older peoples'' walking access towards different destinations.

Keywords: Older commuters' walking; active transport; older people mode choice model, walking access

1. Introduction

The number of older populations is increasing rapidly all over the world. A World Population Prospects (2019) study predicts, one in six people in the world will be over age 65 (16% of the total population) by 2050. The ageing population growth impacts nearly all sectors of society, including financial markets, the demand for goods/services, housing, transportation and social protection. Ageing can face different challenges in mobility and transport. Walking is one of the main modes of transportation and mobility. Walking is a transport mode which is free from traffic congestion and decreases environmental pollution. Walking is one of the most recognised exercises (Watts et al. 2016; Kelly et al. 2018), which has numerous benefits to physical and mental health (Black et al. 2015; Branco et al. 2015; Department of Health 2016; Duncan et al. 2016; Staying Steady 2017; Walk Your Way to Health 2017). For the elderly, risks of developing major cardiovascular, metabolic diseases, muscular weakness and dementia can be reduced through regular walking (McPhee et al. 2016).

2. Literature review

Previous studies covered a range of walking access topics, including health-related aspects, accessibility analysis, mode choice analysis, evaluating the influencing factors on walking and walking behaviour studies. Although walking is related to many benefits, older people are relatively less interested to walk than other adults (Nordbakke 2013; Laverty et al. 2015; Keadle et al. 2016). Researchers, policymakers and health officials promote walking as a sustainable transportation mode (Lee and Buchner 2008; Pucher and Buehler 2010; Yang 2016) specifically for older people. To encourage walking as a mode of transportation, understanding older peoples' travel behaviour is important (Hatamzadeh and Hosseinzadeh 2020). Elderly commuters' travel behaviour is different from other age groups (Nathan et al. 2012; Wong et al. 2017). For instance, less travel, limited walking speed, limited mobility, need for assistance and fear of falling may discourage the elderly from walking (Barnes et al. 2007; Wijlhuizen et al. 2007). For the older people, independent travel needs may be higher than the working-age group to attend more social and health services (Kim and Ulfarsson 2004). Therefore, elderly walking studies need exclusive attention (Borst et al. 2009). Choosing walking as a mode of transport depends on destination accessibility, basic safety, convenience and cost (Schneider 2013).

2.1. Built-in environment and socio-economic study

Many studies have focused on the influence of built-in environmental characteristics and socio-economic variables to analyse older commuters' transport mode choice Zandieh et al. 2019; Zlatkovica et al. 2019).

2.2. Mode choice model study

The mobility mode choice model identifies the variables that influence the travel behaviour for a specific group or area. Yang (2016) discussed various mobility mode choice models which focused on walking behaviour. Duncan et al. (2016) examined the correlation between neighbourhood walkability, transportation mode choice and walking among older adults in Paris, France. Böcker et al. (2017) analysed binomial and multinomial logit regression models to evaluate the elderly trip and mobility mode choice. Despite these research studies, analysing the older commuters' walking preference as a mode of transport is still limited. Most of the older peoples' walkability studies are based on health-related aspects (Notthoff and Carstensen 2015) or the theoretical method (Koschinsky et al. 2017). Older commuters' walking as the travel mode choice has not been widely discussed. Also, considering the elderly walk time, street connectivity and the population is not very common to develop a walking mode choice model. This research intends to address these gaps in the older commuters' walking behaviours. This research develops a walking mode choice model considering a time-based elderly walking accessibility index, built-in environmental characteristics and socio-economic variables.

3. Study area and datasets

For this study, metropolitan Melbourne, Australia older commuters' walking travel datasets are considered. The datasets for metropolitan Melbourne at the SA1 level (Statistical Area level one) is analysed in this study. The datasets such as different trip destinations, older population data, land use mix, street connectivity dataset, travel time dataset, household survey data and census data are collected from various sources. The detailed datasets used for model development in this study are as follows.

3.1. Household survey data

Victorian Integrated Survey of Travel and Activity (VISTA 2016) data sets are a wide range of data, including all age classifications, destinations, travel modes and travel times for all statistical areas. The elderly socio-economic (gender, relation, car license, car numbers, income, disable parking permit, dwelling type, dwell ownership) and home sub-region (built-in environment variables) datasets are extracted from VISTA trip information. More than 18,000 household travel survey was collected. Among that, 7024 older peoples' trip responses were separated from the original datasets using IBM SPSS 26 analysis. From this survey datasets, only 1024 older people use walking to reach a destination.

3.2. Trip destinations/POIs

A detailed point of interest (POIs) database is collected from Australian government open datasets. POIs are considered as the destination/trip purpose. This research examines four major types of POI (shopping centres, health care centres, education centres and recreational centres) which are common destinations for the elderly (Fatima and Moridpour 2019). Figure 1 represents the four POIs distribution within Metropolitan Melbourne SA1s.

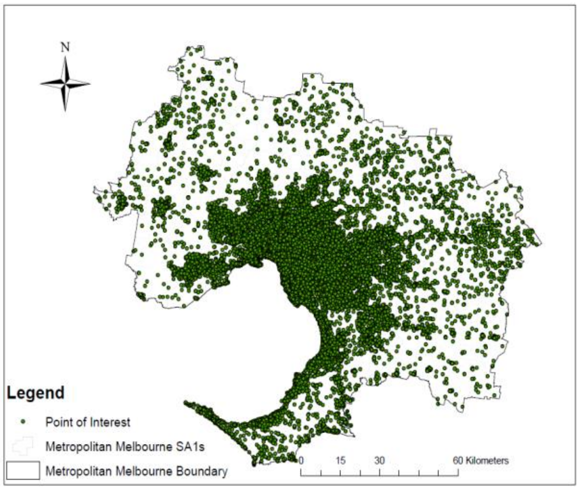

Figure 1: Four POIs coverage within metropolitan Melbourne SA1s

3.3. Older population

The population density is a significant indicator of walking accessibility measure calculation (Frank et al. 2005; Habibian and Hosseinzadeh 2018). According to the Australian Bureau of Statistics (2016), 14% of the total population is aged 65 or over in Metropolitan Melbourne. Population data sets for the elderly are calculated from census data by region-population and AURIN (Australian Urban Research Infrastructure Network). Some inner Melbourne SA1s have a lower elderly population density, whereas some outer Melbourne SA1s have a higher elderly population density. Therefore, considering the elderly population is necessary to calculate the walking mode choice analysis. Depending on the population density, transport planners can prioritise the development area.

3.4. Land use mix

Mixed land use involves a range of complementary land uses located together in a balanced mix, including residential development, shops, employment community, recreation facilities, parks and open space. This study uses an entropy land-use mix method based on Shannon's Diversity Index (Frank et al. 2010; Christian et al. 2011; Mavoa et al. 2018). The urban-related datasets are available from various government open data sources.

3.5. Walk time

Walking speed varies from person to person. The walking speed of older adults is less than the other adults (Azmi et al. 2012). In this study, the walking speed for the elderly is considered as 0.70 m/sec (2.5 km/hr) (Graham et al. 2010; Yang and Ana 2012).

4. Research framework

The framework of older commuters' walking mode choice prediction model is illustrated in Figure 2.

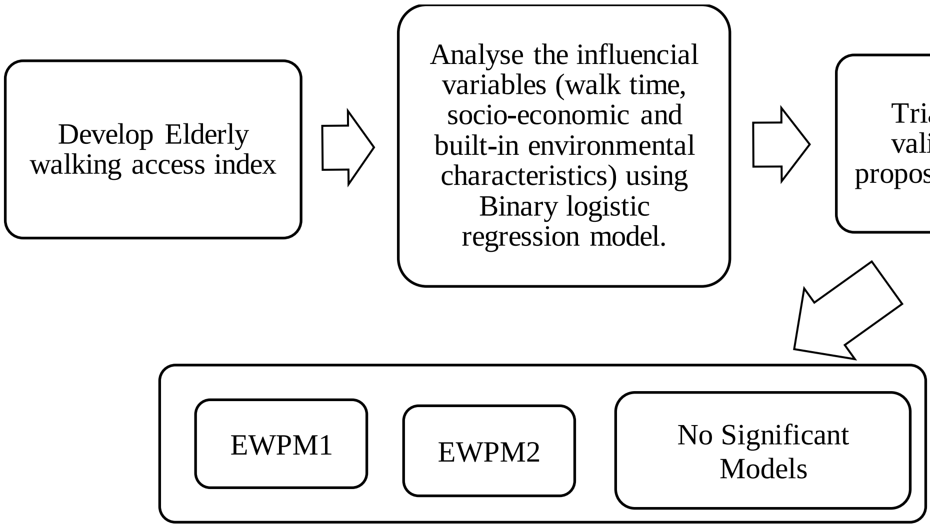

Figure 2: The research framework for older commuters' walking mode choice model

Firstly, this research applies a time-based for model development. The developed time-based index for older commuters considers the elderly total walk time towards a destination from a specific origin (from one specific SA1), street connectivity and the elderly population density. Secondly, a Binary logistic regression (BL) model is used to evaluate the older peoples' walking preference model in this study. To examine the walking preference, several models are developed using IBM SPSS 26 (statistical software). These models are analysed and tested using the influencing variables. Finally, among these tested models, the two most statistically significant models are highlighted. Moreover, the methodology of this study can be described in four steps as follows.

- Develop an older commuter walking accessibility index
- Analysis of all the influential characteristics of older commuters' travel behaviour using Binary logistic regression model.
- Observe the Hypothesised relationship of the variable using IBM SPSS 26.
- Develop two different walking mode choice prediction models to compare and introduce a simplified prediction model structure for elderly travel.

5. Model development

Table 1 (next week) shows the independent/categorical variables, their description, and the correlation relationship with the dependent.

Table 1: Independent variables description

Variables	Description & dummy variable	r*
Elderly walking	It is the dependent variable. In this study whether elderly is walking or not walking is considered.	n/a
	Time-based walking accessibility index	
Elderly walking access index	A measure to evaluate walking access levels for the elderly. In this study, six classifications/dummy are used to identify access levels. The categories are very poor, poor, moderate, good, very good, excellent.	-
	Socioeconomic characteristics	
Gender	Male and female.	+
Relation	Four dummy variables are used: Self, Spouse, Child/Grandchild/Sibling, Other/unrelated/blank.	-
Car license	Three driver's license dummy variable types as Full, Green/Red P, Learners/No/relative/blank.	-
Car numbers	Two dummy variables as one car or more than one cars	+
Income	Four dummy variable as, missing/refused/Negative Income/Zero Income/1-199, 200-299/300-399/400-599, 600-799/800-999/1000-1249, 1250-1499/1500- 1999/2000+.	+
Disable parking permit	Two dummy variables as Holding a permit or not.	-
Dwelling type	Two dummy variables as Separate House or Flat/Apartment/Terrace/Townhouse.	+
Dwell ownership	Two dummy variables as Fully owned/Being purchased or Being rented.	-
	Built environment characteristics	
Home sub-region	Three dummy variables as Melbourne-inner, Melbourne-middle, Melbourne- outer.	-
Land use mix	Consider four destinations: shopping centres, healthcare centres, education centres and recreation centres	-

r^* is the correlation

5.1. Walking accessibility index

The walking index assesses elderly total walk time and population as a Z-score. Datasets are analysed using IBM SPSS 26 and ArcMap 1071 network analyst tool. The time-based walking accessibility index structure for older people is as follows:

$$EWAI1 = (\text{Z-score Walk Time}) + (\text{Z-score } P_{ratio}) + (\text{Z-score Street-connectivity}) \quad (1)$$

$$WT_{SA1i} = \sum_{j=1}^{n} \left(\frac{WT_j^M - WT_{ij}^A}{WT_j^D} \right) \quad (2)$$

Where

WT_{SA1i}= Total walking time for elderly form SA1 centroid,

WT_j^M= maximum walking time to destination j,

WT_j^D= average walking time from an SA1-weighted centroid i to destination j,

$WTij^A$= Desirable walking time to destination j.

$$P_{ratio} = \frac{\sum_1^n Elderly\ Population\ for\ a\ specific\ SA1}{\sum_1^n All\ group\ Population\ for\ a\ specific\ SA1} \quad (3)$$

P_{ratio}= Population ratio,
n= number of SA1.

The elderly walking accessibility index is calculated for metropolitan Melbourne SA1s. The accessibility index is classified into six levels (as very poor, poor, moderate, good, very good and excellent). For a higher index value, the access level is lower (very poor). Inner Melbourne SA1s are more accessible for older peoples' walking access compared to outer Melbourne SA1. For each POI, two thresholds, including the desirable and maximum walking travel times, are defined for the elderly. These values are adopted and converted from Austroads, the Association of Australian and New Zealand Road Transport and Traffic Authorities (Authorities, T. 2011). The maximum (11.6 mins) and desirable time (5.83 mins) is considered to calculate the time component for the elderly walking accessibility index (Equation 2). The desirable walk time is the time, where around 50% of pedestrians feels comfortable. A maximum travel time is where a significant percentage of people would find it within the comfort walking limit. As the walking speed is different for the elderly, the standard travel time also varies compared to the other adults.

5.2. Walking preference model

5.2.1. Elderly walking preference model one (EWPM1)

As mentioned before, the first elderly walking mode choice model, *EWPM1*, considers the walking accessibility index. The *EWPM1* structure is presented in Equation 4.

$$EWPM1, P(Y) = \frac{e^{(\beta_0 + \beta_1 * Elderly\ walking\ accessibility\ index)}}{1 + e^{(\beta_0 + \beta_1 * Elderly\ walking\ accessibility\ index)}} \quad (4)$$

Where
P-Probability of elderly commuters' weekday public transport preference
β_0, β_1 is the regression coefficient.

The odds ratio (*OR value*) identifies the differences in influencing factors between the choice mode (whether walking or non-walking). The *OR value* is calculated using Equation 5.

$$OR = P/(1 - P) \quad (5)$$

5.2.2. Model with elderly walking accessibility index and correlated variables (EWPM2)

The second model, *EWPM2*, is a combination of time-based index and correlated socio-economic components (car licence, gender). Equation 6 is used to predict the elderly walk travels.

$$EWPM2, P(Y) = \frac{e^{\beta 0 + \beta 1 * Elderly\ Walking\ accessibility\ index + \beta 2 * Car\ Licence + \beta 3 * Gender}}{1 + e^{(\beta 0 + \beta 1 * Elderly\ Walking\ accessibility\ index + \beta 2 * Car\ Licence + \beta 3 * Gender)}} \quad (6)$$

6. Results and discussion

The *EWPM1* and *EWPM2* are assessed for all four destination types. Table 2 presents the model accuracy test results for both models. Here "link mode" indicates the elderly walking as the preferred travel mode. Walking usage is dummy coded as "0". Other transport usages (public and private transport) are dummy coded as "1".

Table 2: Model accuracy summary

Description	Dummy Variable	*EWPM1*	*EWPM2*
		Prediction Percentage (%)	
Link mode	1	5897	5894
	0	1127	1130
Overall Percentage		86.0	83.9

Elderly walking dummy coded as "0", Other modes of mobility dummy coded as "1".

From Table 2, around 7024 elderly travel data is analysed using *EWPM1* and *EWPM2*. Overall model accuracy is 86% and 84% for EWPM1 and EWPM2 respectively. From the Table 2 *EWPM1* model accuracy results, 1127 elderly prefer walking as a mobility mode. Similarly, *EWPM2* predict around 1130 elderly prefers walking as a mode of transport towards four POIs. From VISTA (2016), around 1,012 elderly walking as a travel mode to reach a destination. Both model accuracy results match the household survey (VISTA) datasets indicating that the proposed model structures implying the elderly walking prediction correctly.

6.1. *EWPM1* analysis results and discussion

Table 3 represents the results for *EWPM1*. Here, *B* is the coefficient for the target group (elderly walking usage as transportation mobility) and *sig.* represents the *p-value*. A *p-value* is smaller than 0.005 proves the model significance. *Exp(B)* is the exponentiation of the *B* coefficient. *Exp (B) is also* called the *odds ratio (OR).* A negative correlation (*B*) is a relationship between two variables in which one variable increases as the other decreases, and vice versa. For each unit of the target group increases, then the dominant variable coefficient decreases. Wald test is used to test the association between the independent variables (predictors) and the criterion variable (dependent) variable. Wald test (Chi-square test) checks the null hypothesis. This hypothesis is rejected if the *p-value* (*Sig. value*) is smaller than the critical *p-value* of 0.005.

Table 3: *EWPM1* analysis results

Variable	Coefficient *(B)*	Wald Test	df	Sig. *(p-value)*	OR/*Exp(B)*
Elderly walking access index	-1.518	2348.77	1	0.000	0.219
Constant (β_0)	-1.518	2448.77	1	0.000	0.219

From Table 3, the *sig. value* is 0.000 indicates the *EWPM1* is statistically significant. *EWPM1* analysis results show the antagonistic relation between elderly time-based walking access index and walking as mobility mode. It means if the index value increases, the elderly walking as mobility choice decreases. For example, if the index value is higher, it indicates a “very poor” level of elderly walking access (Table 1). The result predicts a higher probability of the elderly not preferring walking transport for travel. Therefore, an *odds ratio*/*EXP(B)*<1 can be interpreted as a decreasing likelihood of being in the target group (elderly walking usage as transport mobility) as scores on the predictor increase. From Table 3, the *Exp (B)* results show that if the index value is higher, the probability of choosing walking as mobility is more minor than choosing other modes (private or public mode of transport) by the elderly. The probability of preferring walking decreases by 0.219 units. In another way, for the highest index value and lower elderly walking access level, the probability of prioritising other modes of transport is

4.57 units. Moreover, the elderly have five times higher possibility of prioritising walking over different mobility modes towards various destination types.

6.2. *EWPM2* analysis results and discussion

EWPM2 is a combination of elderly walk travel time-based index, car licence and gender. The correlation test shows better significant results among these dependent variables. A summarised *EWPM2* prediction model result is presented in Table 4.

Table 4: *EWPM2* analysis results

Variable	Coefficient *(B)*	Wald Test	df	Sig. *(p-value)*	*OR/Exp(B)*
Elderly PT access index	-0.48	0.892	1	0.345	0.618
Car License	0.077	0.543	1	0.461	0.926
Gender	0.702	0.679	1	0.302	2.017
Constant (β_0)	-2.374	9.043	1	0.003	0.093

From Table 4, *EWPM2* analysis results show the opposed relation between elderly time-based walking access index and walking preference as mobility mode. It means the if walking index value decreases, elderly walking as a transport usage increases. As an example, if the index value is lowest, it indicates an “excellent level” (Table 1) of elderly walking access for four POIs. From Table 4, the *Exp (B*) results show that if the index value is higher, the chances to prefer walking is less by the elderly (towards analysed four POIs). The probability of choosing walking decreases by 0.618 units. In another way, for the highest index value and lower walking access level, the probability of prioritising walking is 1.618 units. However, the sig value for the elderly walking index is over 0.005. According to the *p-value* standard, it is not significant.

From Table 4, car licence odd ratio *EXP (B)* is less than 1. In the case of an *odds ratio*/*EXP (B)* < 1, it can be interpreted as a decreasing likelihood of being in the target group as scores on the predictor increase. It demonstrates if the elderly holds a driver license, there is a higher possibility (Unit 1.07) of not choosing walking as a transport mode. From table 4, gender odd ratio *EXP (B)* is greater than 1. If *OR/Exp(B)* > 1, it is interpreted as an increased likelihood of being in the target group (walking as transport usage) on the dependent variable. The decrease of elderly walking access level and specific gender (male or female) will not choose walking as a mobility mode. However, the categorical variables are not significant with the independent variable "Travel mode (walking)". The reason might be the developed elderly walking accessibility index variables are somehow correlated to other dependent variables. For example, the index already calculated the elderly population, which might conflict with the variable "gender". Besides, the *sig* value *(p-value*) for categorical variable gender and car licence is not significant (over 0.005). Moreover, these independent variables may be similar or positively correlated, affecting the *EWPM2* model performance. Therefore, *EWPM2* cannot be considered as a proper prediction choice model for the elderly walk.

6.3. Model validation

As the model *EWPM2* is not significantly correct; therefore, only *EWPM1* is tested. To check the model goodness fit, Omnibus and Hosmer & Lemeshow is conducted. Table 5 summarises the validation test results for *EWPM1*.

Table 5: EWPM1 validation comparison summary

Statistical test		EWPM1
Omnibus test for model	Chi-square	7.066
	df	12
	P-value	0.003
Hosmer and Lemeshow test for model	Chi-square	12.162
	df	8
	P-value	0.144

The Omnibus statistical test that explains variance in a dataset is significantly greater than the unexplained variance. The Omnibus Tests of model coefficients contains results from the likelihood ratio chi-square tests. If the *p-value* is less than 0.005, then the model is statistically valid. Table 5 indicates that the EWPM1 fits the data significantly better as $p<0.005$.

The Hosmer–Lemeshow (HL) is another statistical test for goodness of fit for Binary models. It tests whether the datasets properly fit into the model or not. This HL test calculates if the observed prediction output results coordinate with the expected output results. HL test fit better if the model result is non-significant. The limit for HL *sig. value* is in between 0 to 1. If the *p-value* is closer to 0, then the model is non-significant. Similarly, if the *sig value* is more relative to 1, it is significant. From Table 5, the *p-valu*e is 0.144, which is closer to 0. It rejects the null hypothesis, and therefore the model fits the data.

Moreover, from all the above analysis and validation tests, it can be observed the proposed elderly walking preference model one (*EWPM1*) fits elderly walking behaviour. The proposed *EWPM1* is controlled by the elderly walking access level, nearest POI (from specific SA1), street connectivity and elderly population in a walking accessibility index. These variables are correlated to other socio-economic and build-in-environmental variables. Therefore, instead of using several categorical variables, only the elderly time-based access index can be easily applicable.

7. Conclusion and future research direction

This study demonstrates different influential factors of older commuters' walking travel mode preferences. The mode choice model, including the time-based index, is most significant to analyse elderly travel behaviour. The results show the elderly access level towards a destination is an essential factor for the elderly's walking preferences. For higher walking access levels (Lower walking index value), the probability of choosing walking as mobility mode is greater by older commuters. As the model calculation also consider population and street connectivity, it provides more precise analysis result for elderly. The model approach is also applicable to other geographic locations or cities around the world. Both the index and model can help disabled commuters' travel behaviour analysis. This time-based walking access prediction model is also applicable for other adult commuters with minor modifications (walk time, walk speed).

This study examines the older commuters' weekdays travel datasets. The walk time is evaluated for four specific destination types. Future research may include more destination types and weekend travel to the analysis of the choice model using the destination distance. The urban and transport policy planners can use the developed time-based walking index and mode preference model for future urban development. The index indicates the elderly walking access levels and population, so higher elderly populated areas can be provided with street signs.

Frequent street signs and travel time between different origins and POIs can provide more confidence to walk for older commuters (Hess 2012). Future urban and policy planners can modify the distribution of various essential destinations. The model EWPM1 can be easily applicable to analysing the prediction results and improvements for the newly developed plan.

8. References and citations

Authorities, T. (2011), Austroads, Application of Accessibility Measures. Report AP-R397-11. Austroads, Sydney, New South Wales, Australia.

Azmi, D. I., Karim, H.A., Zamreen, M. and Amin, M. (2012), Comparing the Walking Behaviour between Urban and Rural Residents, *Procedia - Social and Behavioral Sciences*, 68, 406 – 416.

Barnes, J, Morris, A, Welsh, R, Summerskill, S, Marshall, R, Kendrick, D, Logan, P, Drummond, A, Conroy, S, Fildes, B and Bell, J. (2016), Injuries to older users of buses in the UK, *Planning and Operations*, 8(1), 25-38.

Black, S.V., Cooper, R., Martin, K. R., Brage, S., Kuh, D. and Stafford, M. (2015), Physical Activity and Mental Well-being in a Cohort Aged 60–64 Years, *American journal of preventive medicine*, 49 (2), 172-180.

Böcker, L., van Amen, P. and Helbich, M. (2017), Elderly travel frequencies and transport mode choices in Greater Rotterdam, the Netherlands, *Transportation*, 44(4), 831-852.

Borst, H.C, de Vries, S.I, Graham, J.M.A, van Dongen, J.E.F, Bakker, I and Miedema, H.M.E (2009), Influence of environmental street characteristics on walking route choice of elderly people, *Journal of Environmental Psychology*, 29, 477-484.

Branco, J.C., Jansen, K., Sobrinho, J.T., Carrapatoso, S., Spessato, B., Carvalho, .J, Mota, J. and da Silva, R.A. (2015), Physical benefits and reduction of depressive symptoms among the elderly: results from the Portuguese "National Walking Program", *Ciência & Saúde Coletiva*, 20 (3), 789-795.

Christian, H.E, Bull, F.C, Middleton, N.J, Knuiman, M.W, Divitini, M.L, Hooper, P, Amarasingh, A, and Corti, B.G. (2011), How important is the land use mix measure in understanding walking behaviour? Results from the RESIDE study, *International Journal of Behavioral Nutrition and Physical Activity*, 8, 55.

Department of Health, Stay Active (2016), A Report on Physical Activity from the Four Home Countries' Chief Medical Officers. Available online: https://www.gov.uk/government/uploads/system/.

Duncan, D.T., Méline, J., Kestens, Y., Day, K., Elbel, B., Trasande, L. and Chaix, B. (2016), Walk Score, Transportation Mode Choice, and Walking Among French Adults: A GPS, Accelerometer, and Mobility Survey Study, *International Journal of Environmental Research and Public Health*, 13, 611.

Fatima, K. and Moridpour, S. (2019), Measuring Public transport Accessibility for Elderly, The 6th International Conference on Traffic and Logistic Engineering (ICTLE), Bangkok, Thailand, 1-6, 2018.

Frank, L. D, Schmid, T. L, Sallis, J. F, Chapman, J & Saelens, B. E 2005, Linking objectively measured physical activity with objectively measured urban form: Findings from SMARTRAQ, *American Journal of Preventive Medicine*, 28(2S2), 117–125.

Frank, L. D, Sallis, J. F, Saelens, B. E, Leary, L, Cain, K, Conway, T. L and Hess, P. M. (2010), The Development of a Walkability Index: Application to the Neighborhood Quality of Life Study, *British Journal of Sports Medicine*, 44 (13), 924–933.

Graham, J., Fisher, S., Bergés, I., Kuo, Y. and Ostir, G. (2010), Walking Speed Threshold for Classifying Walking Independence in Hospitalized Older Adults, *Physical Therapy*, 90, 1591–1597.

Habibian, M. and Hosseinzadeh, A. (2018), Walkability index across trip purposes, *Sustainable Cities and Society*, 42, 216-225.

Hatamzadeh, Y. and Hosseinzadeh, A. (2020), Toward a deeper understanding of elderly walking for transport: an analysis across genders in a case study of Iran, *Journal of Transport & Health*,19,100949.

Hess, D.B. (2012), Walking to the bus: perceived versus actual walking distance to bus stops for older adults, *Transportation*, 39, 247–266.

Keadle, S., McKinnon, R., Graubard, B. and Troiano, R. (2016), Prevalence and trends in physical activity among older adults in the United States: a comparison across three national surveys, *Preventive Medicine*, 89, 37–43.

Kelly, P., Williamson, C., Niven, A.G., Hunter, R., Mutrie, N. and Richards, J. (2018), Walking on sunshine: scoping review of the evidence for walking and mental health, *British journal of sports medicine*, 52 (12), 800-806.

Kim, S. and Ulfarsson, G. (2004), Travel mode choice of the elderly: effects of personal, household, neighborhood, and trip characteristics, *Transport Research Record*, 1894, 117–126.

Koschinsky, J, Talen, E & Alfonzo, M. (2017), How walkable is Walker’s paradise? *Environment and Planning B: Urban Analytics and City Science*, 44 (2), 343-363.

Laverty, A., Palladino, R., Lee, J. and Millett, C. (2015), Associations between active travel and weight, blood pressure and diabetes in six middle income countries: a cross sectional study in older adults, *International Journal of Behavioral Nutrition and Physical Activity*,12 (1), 65.

Lee, I.M. and Buchner, D.M. (2008), The importance of walking to public health, *Medicine & Science in Sports & Exercise*, 40 (7s), S512–S518.

Mavoa, S., Eagleson, S., Badland, H.M., Gunn, L., Boulangé, C., Stewart, J. and Giles-Corti, B. G. (2018), Identifying appropriate land-use mix measures for use in a national walkability index, *The Journal of Transport and Land use*, 11(1), 681-700.

McPhee, J.S., French, D.P., Jackson, D., Nazroo, J., Pendleton, N. and Degens, H. (2016), Physical activity in older age: perspectives for healthy ageing and frailty, *Biogerontology*, 17, 567–580.

Nathan, A, Pereira, G, Foster, S, Hooper, P, Saarloos, D and Corti, B.G (2012), Access to commercial destinations within the neighborhood and walking among Australian older adults, *International Journal of Behavioral Nutrition and Physical Activity*, 9, 33.

Nordbakke, S. (2013), Capabilities for mobility among urban older women: barriers, strategies and options, *Journal of Transport Geography*, 26, 166–174.

Notthoff, N. and Carstensen, L. L. (2015), Promoting walking in older adults: Perceived neighborhood walkability influences the effectiveness of motivational messages, *Journal of Health Psychology*, 22 (7), 834-843.

Pucher, J. and Buehler, R. (2010), Walking and cycling for healthy cities, *Built Environment*, 36 (4), 391–414.

Schneider, R.J. (2013), Theory of routine mode choice decisions: An operational framework to increase sustainable transportation, *Transport Policy*, 25, 128–137.

Staying Steady (2017), Keep Active and Reduce Your Risk of Falling, Age, UK, Available online: http://www.ageuk.org.uk/Documents/EN-GB/Information-

Victorian Integrated Survey of Travel and Activity (VISTA). Department of Transport, Melbourne, 23 Victoria, Australia, 2016, https://transport.vic.gov.au/about/data-and-research/vista.

Walk Your Way to Health (2017), Available online: http://www.ageuk.org.uk/health-wellbeing/keeping-fit/walkyour-way-to-health/how-walking-can-improve-your-health.

Watts, A., Walters, R.W., Hoffman, L., Templin, J. and Buchowski, M. (2016), Intra-Individual Variability of Physical Activity in Older Adults With and Without Mild Alzheimer's Disease, *PloS one*, 11 (4), 0153898-0153898.

Wijlhuizen, G. J., de Jong, R. and Hopman-Rock, M. (2007), Older persons afraid of falling reduces physical activity to prevent outdoor falls, *Preventive Medicine*, 44, 260–264.

Wong, R, C.P, Szeto, W.Y, Yang, L, Li, YC and Wong, S.C (2018), Public transport policy measures for improving elderly mobility, *Transport Policy*, 63,73-79.

World Population Prospects (2019) Revision, Active Ageing: Policy F, 2002 Active Ageing, 2002. A Policy Framework. World Health Organization.

Yang, Y. and Ana, VD. (2012), Walking Distance by Trip Purpose and Population Subgroups, *American Journal of Preventive Medicine*, 43, 11-19.

Yang, Y. (2016), A dynamic framework on travel mode choice focusing on utilitarian walking based on the integration of current knowledge, *Journal of Transport & Health*, 3 (3), 336–345.

Zandieh, R.; Martinez, J. and Flacke, J. (2019), Older adults' outdoor walking levels and neighbourhood green spaces characteristics, *International Journal of Environmental Research and Public Health*, 16(22), 4379.

Zlatkovica, M, Zlatkovicb, S, Sullivan, T, Bjornstad, J and Shahandashtie, SKF. (2019), Assessment of effects of street connectivity on traffic performance and sustainability within communities and neighborhoods through traffic simulation, *Sustainable Cities and Society*, 46.