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Measuring Accessibility in low density Housing: The Role of neighbourhood design

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Abstract. Accessibility is a key contributor to the quality of life experienced by residents and others. This paper asks how might accessibility be measured in different contexts? Quantitative analyses were undertaken, and 247 residents were surveyed in three suburbs. Pearson correlations was used to investigate the relationship between perceived accessibility and a number of independent social and physical neighbourhood design variables. The findings suggest that a quantitative method can be usefully conducted to measure the perception of residents toward their social-spatial environment. The results presented that accessibility is strongly associated with physical design features, even with interaction of socio-demographic variables. Hierarchical multiple regression was also showed that some of the physical characteristics significantly predicted accessibility particularly street type, open space provision and trees coverage after socio-economic factors controlling such as income and length of residence. This indicates that well designed neighbourhoods can be more accessible for residents. The findings also suggest that accessibility associated with the social and physical needs of residents can be critical influences that planners and decision maker need to consider when designing for sustainable environment in contemporary suburban contexts.

Keywords: Accessibility, Neighbourhood design, Sustainability, Environmental characteristics

1. Introduction

This paper examines the impact of physical environment characteristics on accessibility in suburban neighbourhoods. Accessibility is defined as the presence of facilitates within a specified neighbourhood and is set as indicator that measure “access relationship between an origin and a destination” [1].
In general, the association between equity and accessibility is identified as “the notion of equity is paramount in research that focuses on determining what factors account for, or are correlated with, territorial variation in service delivery” [1]. Thus, accessibility is an approach used to define equity in neighbourhoods.
Accessibility indicates also to the extent of easy connection with a site that can be obtained, and it hence can measure the relative opportunity for interactions with a given phenomenon such as open spaces and parks [2]. Accessibility is an important indicator which increases the attendance of residents in the green spaces and hence encourage social interactions [3].

Moreover, accessibility is considered as well-established component of concepts of effective sustainable urban form [4, 5]. Research has suggested that sustainable development pattern should consider the increased of access between inhabitants; their work places and the required services. Accordingly, accessibility is linked to the principles of smart development and active living environments [6], since residents access to their life requirements is seen as particularly significant. Thus, measures of accessibility were used broadly as part to evaluate of built environment effects on health. In this way, walkability and access to service areas are important elements of the sustainability evaluation due to established serviced places will result lower carbon emissions [7]. Higher accessibility to jobs and services contributes to transport costs, which is related to sustainable urban form. Pedestrian oriented streets are supposed to have an impact not only on place quality but also on the extent to which residents

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are tending to walk, Hence, it is suggested that strategies should be used to encourage more pedestrian oriented streets [6].

The role of neighbourhood design has been identified as contributor to quality of life via enhanced accessibility and wide recreational open space opportunities but within urban areas, presence of facilitates is inequitably distributed. Access is frequently highly constructed according to demographics factors such as income, ethno-racial characteristics, age, gender, and other axes of difference [8].

Recent studies have acknowledged the association between accessibility and the physical design of neighbourhoods, demonstrated significance of access to facilities and green spaces and linked between parks proximity and physical activity. For example, it has been found that access to parks and open spaces is more likely to encourage physical activity if they meet aesthetic indicators such as less traffic, provision of sidewalks and trees coverage [9, 10].

There is inconsistency between perceived accessibility as subjective measures and physical accessibility as objective measures [11-13]. Due to perceived accessibility is not associated with actual spaces facility or physical distance [14]. For example, while study in Melbourne, Australia has empirically showed that "lower income residents were more likely to have mismatches between their perceptions of the physical environment and objective measures" [11], neighbourhoods residents in UK who lived closer to open spaces and parks reported less perceived access to parks and less frequently than residents in more wealthy areas [12]. Thus, it suggests that perceived accessibility is significant to comprehend and expect social behaviours

However, although accessibility has been recognised as a multidimensional concept, little research has empirically considered physical and social factors that influence perceived the accessibility in residential neighbourhoods. Moreover, studies have showed inconsistent impacts of some factors on Accessibility. To fill this gap, surveys is conducted in low density neighbourhoods that ring Australian cities, to empirically explore impact of neighbourhood design on accessibility. Thus, this study answers the questions; (1) what design features of neighbourhoods predict accessibility in low-density housing? and (2) which of these characteristics are the strongest predicators of accessibility.

Primary data were collected in three suburbs with socially homogenous status but with varied physical features depending on when those suburbs have been established. Questionnaire were undertaken to collect the data of the scale-items representing accessibility. The findings correspond with recent studies show that higher perceived accessibility is associated with sustainably designed neighborhood. The most vital features affecting perceived of access to residential neighbourhood were street layout, adequate amount of open spaces in the neighborhood, tree coverage and income. Less important, but statistically significant dwelling type. Thus, physical design is seen to make greater contribution to accessibility than sociodemographic factors in three suburban neighbourhoods.

2. Methodology

Quantitative methodology is used to investigate the influence of designed neighborhood on accessibility in low density housing. Data was collected via survey of residents in three suburbs with equivalent socio-economic profiles in Victoria, Australia. The three suburbs – "Belmont, Grovedale and Waurn Ponds" in "the City of Greater Geelong, which is the second largest city in Victoria. They are mainly categorized by low density, single land uses, single-family housing and car dependence (Figure 1.) They were selected for two key reasons: (1) socioeconomic equivalence, and (2) variety of design, as each was developed through different eras of suburban development and hence, they vary in urban design arrangement and architectural styles.

Figure 1. The three suburbs layout and selected residential streets source (NearMap)

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2.1. Data collection

600 residents were selected randomly and received a plain language statement, consent form and questionnaire. Each of the three neighbourhood-areas selected for study was occupied by approximately 260 houses in eight streets. Predicting a 40% response rate, in order to receive 80 completed questionnaires from each of the three neighbourhood-areas, 200 households in each suburb, randomly selected, received the questionnaire via their mailboxes

Surveys were completed by 247 residents recruited from 3 neighbourhoods in Geelong, Australia. Two methods of data collection are carried out: Questionnaires were delivered to residents' mailboxes in 24 streets.

Responses were returned via provided "addressed envelopes", which was a Deakin envelope addressed to the "School of Architecture and Built Environment". 184 completed questionnaires were collected in total, and returned the questionnaires: 68, 65 and 51 and 51 from Belmont, Grovedale, and Waurn Ponds respectively. In order to confirm the social homogeneity of the selected suburbs evidenced by census data, socio-demographic and residential features collected involved household tenancy, age, income, gender, length of residence, family number, number of children and education in years.

In order to increase the sample size, a direct survey was also conducted in public space proximate to the neighborhood library of each suburb: 63 residents were completed from the three neighbourhoods. Accordingly, residents reported perceived access to neighbourhoods' spaces and facilities via measuring residents' contentment with physical qualities of their neighbourhoods in equate with street networks within neighborhood spaces.

2.2. Survey instrument

The instrument comprised of 4 scales determining perceptions of residents neighbourhood experience through measuring : (1) neighbourhood attachment [15, 16]; (2) Neighbourhood satisfaction [17]; (3) Neighbouring [18, 19]; and (4) walkability and safety [3, 20], which are defined in detail elsewhere [21]. All the questionnaires consisted of closed-ended questions and all answers were ranked according to Likert scale (Figure 2).

Figure 2. Show the physical environment features of the three selected suburbs.

2.3. *Measurement of urban design characteristics*

Five categories of physical features were measured. As these measures are described in detail in previous study [21, 22], (Figure 3).

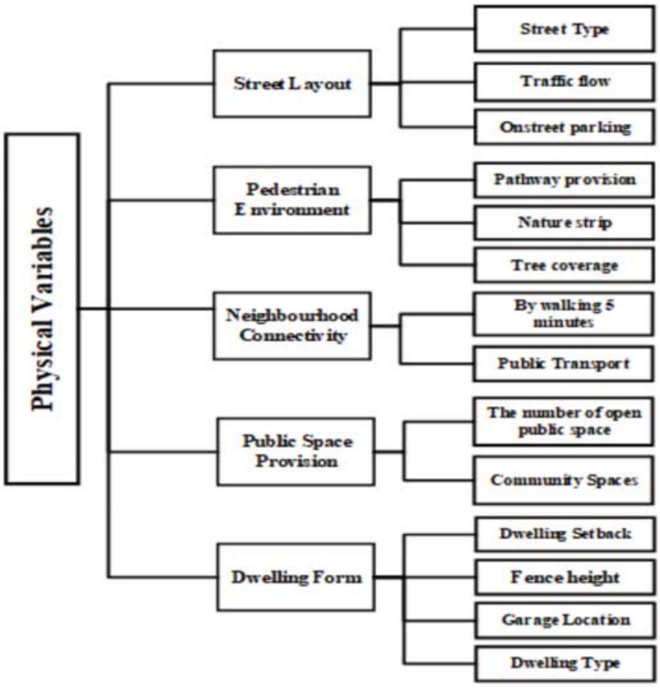

Figure 3. Measures of the physical characteristics of neighbourhood suburbs

3. Results

3.1. Principal component analysis

As detailed in previous study, Exploratory Factor Analysis is conducted to reveal the fundamental structure of the large established variables comprised of four scales used in the study. The items of the 4-scale neighbourhood experience tool were subjected to PCA using SPSS. Prior to performing PCA, the suitability of the data for factor analysis was assessed. Inspection of the correlation matrix showed the existence of many coefficients of 0.3 and above. Thus, three factors were extracted: factor 1 represents a combination of neighbourhood attachment and satisfaction, which is named neighbourhood contentment, factor 2 represents active socialising includes supportive acts of neighbouring and social ties between residents, and factor 3 accessibility includes items representing physical qualities of street design related to perceptions of walking, local access and safety in a neighbourhood. This paper is focused on the results of Accessibility (Table 1).

Questionnaire items	Loadings
Parked cars impede walking	0.611
Going into this neighbourhood means going around in circles	0.609
It is easy to cycle around	–0.586
It is dangerous to cycle	0.576
Parking places and parking lots are lacking	0.561
Streets are wide enough	–0.542
There is not enough space to walk	0.470
I feel uncomfortable walking where there are no footpaths	0.452
I often see strangers who make me feel uncomfortable when I walk	0.389
This neighbourhood is well-suited for handicapped people	–0.376
This neighbourhood is too cut off from the rest of the city	0.371
There is a good availability of parking spaces	–0.326
Cronbach's alpha	**0.776**

Table 1. Identified Questionnaire for the Accessibility

3.2. Multiple regression analyses

Hierarchical multiple regression was used, preliminary with intercept-only socio-demographic features to examine how much physical design variables predict the accessibility after controlling of socio-demographic indicators (length of residence; income; household numbers and level of education), which are only significantly correlated with accessibility).

3.2.1. Regression for predicting Accessibility from street layout

Hierarchical multiple regression was used to find if the street type indicators predict accessibility, after controlling for the influence of sociodemographic factors, which were entered at step 1, showed 8.5 % of the variance in perceived Accessibility. In step 2, street type; traffic flow; and on-street parking, the variance of this model explained 10.6 %, $F(7, 235) = 4$, $p < 0.01$. The three control variables defined an additional variance in Accessibility (4.1%) after socio-demographic factors controlling. R squared variation = 0.41, F change $(4, 238) = 3.8$, $p < 0.01$. In the final model, two variables were statistically significant, with Street type and Income recording higher beta values (beta = –0.19, $p < 0.01$).

3.2.2. Regression for predicting Accessibility from pedestrian environment

Hierarchical multiple regression was used to find if pedestrian environment variables (footpath, nature strip and tree coverage) predicted Accessibility after controlling of the sociodemographic factors, which were entered at step 1, and made significant contribution to the regression model, $F(4, 238) = 5.5$, $p < 0.001$, and showed 8.5% of the variance in perceived Accessibility. In step 2, footpath; nature strip and tree coverage, the variance of the model explained 11%, $F(7, 235) = 4.1$, $p < 0.05$. The three control variables accounted an additional variance in Accessibility 2.4% after socio-demographic variables controlling, R^2 change = 0.024, F change $(3, 235) = 2.1$, $p < 0.05$). In the final model, two variables made significant influence, income recording beta value (beta = –0.19, $p < 0.01$) and tree coverage (beta = –0.19, $p < 0.05$).

3.2.3. Regression for predicting Accessibility from neighbourhood connectivity

Hierarchical multiple regression was used to find if neighbourhood connectivity predicted Accessibility after Socio-demographic factors controlling, which entered in first model. The significant contribution in the regression model was $F(4, 238) = 5.5$, $p < 0.001$, and 8.5% of the variance in perceived Accessibility. In step 2, the two physical variables explained the total variance 9.5%, $F(6, 236) = 4.1$, p

< 0.05 and explained an additional 1% of the variance in Accessibility. R^2 change = 0.01, F change (2, 236) = 1.3, $p < 0.05$. In the final model, only Income remained statistically significant, recording beta value (beta = 0.20, $p < 0.01$). However, this suggests that neighbourhood connectivity did not have an effect beyond the effects of Income.

3.2.4. Regression for predicting Accessibility from public space provision

Hierarchical multiple regression was used to find if public space provision predicted Accessibility after controlling for the influence of four socio-demographic variables which were entered at step 1, and showed significant contribution in the regression model, F (4, 238) = 5.5 $p < 0.01$, and 8.5% of the variation in Accessibility. In step 2 the two variables explained total variance 10.6 %, F (6, 236) = 4.7, $p < 0.01$ and described only an additional 3 % of the variance in Accessibility. R^2 change = 0.03, F change (2, 236) = 4.7, $p < 0.01$. In the final model, two variables were statistically significant, with Open spaces recording a higher beta value (beta = –0.25, $p < 0.01$) than Income (beta = –0.19, $p < 0.01$).

3.2.5. Regression for predicting Accessibility from dwelling form

Hierarchical multiple regression was used to find if dwelling form variables predicted Accessibility after controlling for the influence of four socio-demographic variables which were entered at step 1, and made significant influence on the regression model, F (1, 241) = 5.5, $p < 0.001$, and showed 8.5% of the variance in perceived Accessibility. In step 2, the four physical variables accounted variance, 12%, F (8, 234) = 4.5, $p < 0.05$ and explained an additional 5% of the variance in Accessibility. R^2 change = 0.05, F change (4, 234) = 3.2, $p < 0.05$. In the final model, only income recording a higher beta value (beta = –0.19, $p < 0.01$) and dwelling type (beta = –0.13, $p < 0.05$) (Figure 4).

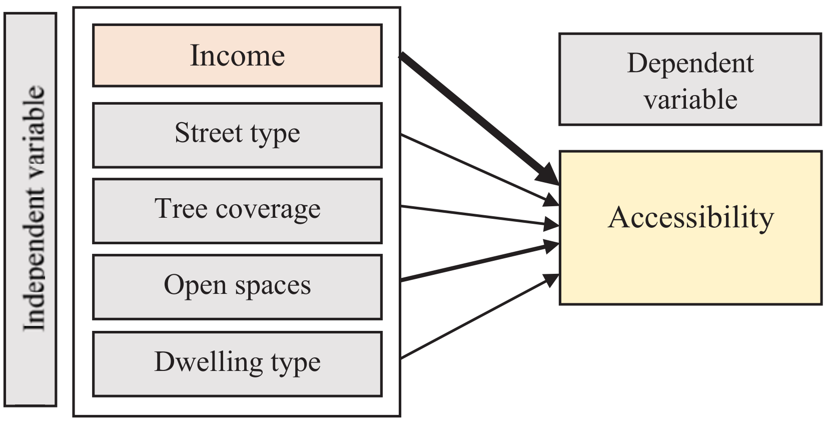

Figure 4. Regression analysis for predicting accessibility from physical variables (Only the significant predictors are shown)

4. Discussion

The findings of this study support the hypothesis that designed neighborhoods are contributed to accessibility.

The results of the hierarchical regression indicate that street layout significantly predicted Accessibility after accounting for socio-demographic factors: income; length of residency; household number and education level. While, both income and street type significantly contribute to perceived Accessibility, traffic-flow and on-street car parks not associate with Accessibility.

The results of the hierarchical regression that investigated the power of footpaths, nature strips and tree coverage in predicting accessibility indicated pedestrian environment was not significant in predicting accessibility. The findings show that income is a much stronger predictor of accessibility in the first and second model. This suggests that inclusion of income reduced the impact of pedestrian environment and this revealed no significant change in predicting accessibility. This result is inconsistent with prior research that showed significant connections between open spaces use, for instance parks and the presence of footpaths [23]. However, tree coverage significantly predicted accessibility. Although both variables significantly correlated with accessibility, the results indicate that connectivity by walking and connectivity by transport did not predict accessibility. The results of the fourth hierarchical regression indicated that public open space provision with walking distance significantly predicted accessibility when socio-demographic variables were controlled for.

While dwelling type was the only physical variable of dwelling form that significantly contributed to accessibility, the predictive power was small compared to that of income, which seemed to be the best predictor in the first and second steps. This finding suggests that income is the most contributor factor to accessibility perception than dwelling form. Such findings also suggest pedestrian-oriented streets with short blocks provide residents many choices to reach their destination and facilitate access to their neighbourhood, which in turn impact neighbourhood satisfaction. Few studies have identified how design addresses the role of street layout to enhance suburban environment and which street type has a greater contribution to connectivity. However, other research has recognised that neighbourhood street networks, which are characterised by a grid street type with short blocks, encourage walking and create friendly residential environments compared to disconnected and curvilinear street types [20]. This finding consistent with research found open spaces that are friendly accessible space is more frequently used by residents than car dependent space [13].

Recent research also found that physical features, particularly proximity, a pleasant walking space and an appropriate amount of open spaces such as parks in the neighbourhood, are the most significant influences of perceived accessibility [13]. The finding that neighbourhood connectivity did not significantly contribute to accessibility is in contrast with other studies finding that accessibility associated with pedestrian friendliness might lead to reduced car dependence [24], as connected walking environments increase accessibility and enhance walkability of community members [25, 26]. At the same time, accessibility was found to facilitate more walking in neighbourhood spaces [27].

However, some limitations are required to acknowledge: social factors that can be measured in future research were not within the focus of this research: (1) crime, social and cultural diversity, (2) shared activities, (3) safety, and (4) active lifestyle; due to the overall sample size, it could be argued that there were too few respondents per street to adequately model neighbourhoods at the suburb level.

5. Conclusion

This study sought to determine if built environment characteristics or socio-demographic factors have the greatest impacts on accessibility with low-density suburban neighbourhoods. The research offers clear evidence that even with controlling of socio-demographic factors, perceived accessibility is associated with provision of accessible open spaces, street type, trees coverage, and dwelling type.

The study showed that physical variables affecting accessibility differ in their prediction power. Of the 14 neighbourhood design variables, provision of open spaces and street type had equal influence to income in predicting accessibility, while tree coverage followed by dwelling type had smallest influential power compared to income. This in turn suggests that overall design of neighbourhoods can have a strong role in the perception of accessibility, even after controlling for socio-demographic and other characteristics in the context of low-density suburbs. Moreover, income significantly impacts accessibility and has independent influence compared to physical design variables. This also suggests that inclusion of physical variables cannot reduce the contribution of income. Accordingly, it can be argued that accessibility can be a multidimensional measure and an instrument that can be developed to include all the potential factors.

Although this research was focused on measured accessibility in low density context, the scale could be applied in high density area to examine the extent to which the physical design impact the accessibility particularly walking distance to opens paces and parks. Future research would be beneficial to understand whether the accessibility measures that extracted in this study is applicable to different cultural and demographics backgrounds.

Consequently, it can be suggested that, in low density suburbs, design should consider a number of variables of friendly and walkable neighbourhoods in particular grid street types with good connectedness; high numbers of open spaces within walking distance; tree coverage; and sufficient pedestrian access. These features can be associated with increased accessibility. Thus, to strengthen accessibility to neighbourhood spaces and then develop more sustainable communities in suburban contexts, is clearly within the role of urban designers and architects, which need to address the specific needs of residents according to demographic characteristics especially the income.

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