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PEDESTRIAN CONNECTIVITY: A FOCUS ON RESIDENTIAL NEIGHBOURHOOD SIDEWALKS TO PROMOTE ACCESSIBILITY TO PUBLIC PARKS

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Public parks play a pivotal role in improving community life in residential neighbourhoods, with many individuals integrating a daily walk to a park near their home as part of their routine. A crucial element of the pedestrian infrastructure that promotes walkability is the use of sidewalks. However, a decline in the usage of both public parks and sidewalks has been reported in residential areas of South Africa due to the challenges discussed in this paper. Studies suggest that ample pedestrian pathways leading to public parks may enhance park usage. This study aims to analyse the functionality of sidewalks in a suburb in Bloemfontein city in South Africa as non-motorised transportation routes and to propose design guidelines for improvement to promote access to public parks in the suburb. The study employs the Conjoint analysis technique to identify factors deterring pedestrians from using sidewalks, thus hindering access to public parks. The results emphasise that the physical layout, and the perceived and actual safety of pedestrians are the primary factors impacting sidewalk usage. For instance, pedestrians frequently opt for roadways over sidewalks despite potential risks, mainly due to insufficient pedestrian-friendly infrastructure. The findings suggest that infrastructure upgrades, connected sidewalks and parks, safety measures, inclusive design, community awareness programs, and periodic reviews of pedestrian needs can lead to cities that promote active lifestyles and become more inclusive, sustainable, and conducive to holistic well-being. Furthermore, this study demonstrates that the Conjoint analysis technique is a powerful tool in urban planning, providing valuable insights into pedestrian preferences and their implications for infrastructure improvement decisions.

Key words**: public parks, residential neighbourhood sidewalks, pedestrian connectivity, accessibility, urban planning.**

INTRODUCTION

It is common knowledge that urban green spaces provide city dwellers with many physical and mental health benefits. Therefore, it is no surprise that green spaces are often included in spatial planning ideologies (LeGates *et al.*, 2020). For instance, Olmsted advocated for landscape gardening to improve the city's well-being and the health conditions, whereas Howard's garden city specified a specific amount of green space surrounding the city to promote social and community benefits (LeGates *et al.*, 2020). Beyond these ideologies, research promotes access to green urban parks in local neighbourhoods within walking distance to promote mental health (Wood *et al.*, 2017). Furthermore, access to an expansive park network not only promotes the health and well-being of people but also their quality of life (Albers *et al.*, 2010; Larson *et al.*, 2016). Wilson and Xiao (2023) further demonstrate that urban parks improve population health and well-being and serve as a cost-saving mechanism for the medical system. Urban parks also provide spaces for social interactions, community events (e.g. 2024 national elections in South Africa), and recreational activities to promote social cohesion (Parker, 2018). Furthermore, parks contribute to placemaking in cities, which enhances the urban quality of life and promotes investment, job creation and leisure

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activities to transform public spaces into user-friendly and sustainable urban environments (Lastochkina, 2021).

The numerous benefits of urban parks (referred to as public parks in this paper) can only be fully realised through thoughtful urban planning that prioritises the development of accessibility to these places (Giles-Corti *et al*., 2005). Sidewalks serve as mobility pathways for pedestrian traffic to increasing connectivity and promoting walking (National Association of City Transportation Officials, 2024). Therefore, pedestrian infrastructure in urban planning is critical to enhance public park accessibility (Krambeck, 2006). The vitality of public parks and open spaces is intrinsically linked to their accessibility, which is largely determined by pedestrian infrastructure such as sidewalks, adequate lighting, and well-maintained access roads (Das and Honiball, 2016). Paraskevopoulos *et al.* (2020) note that walkability features such as adequate sidewalks and pedestrian infrastructure enhance the connectivity of the area, whereas, Bartzokas-Tsiompras *et al.* (2021) highlight the lack of inclusivity of such features for people in wheelchairs. This underscores the potential of well-conceived pedestrian spaces to foster urban vibrancy and social engagement (Tong and Bode, 2022), since they are not merely a space for movement but also social space (Mehta, 2007). Despite general agreement on the importance of walkability, Gehl (2020) identifies a research gap in understanding the adaptation and perception of pedestrian infrastructures across different urban cultures and settings. Montgomery (2013) highlights the unique challenge faced by developing nations in balancing pedestrian-friendly urban development with rapid urbanisation, a challenge that is particularly pronounced in the South African context, due to its distinctive socio-political history and urban dynamics (Albers *et al*., 2010). Central to this discussion is the concept that seamless and unobstructed pedestrian access to public parks promotes the associated benefits of these spaces, which align with the change in the perception of spatial planning to focus on sustainable, inclusive and liveable cities (Todes, 2011). Moreover, public parks were chosen because they significantly enhance community life by providing spaces for recreation, exercise, and social interaction, directly impacting public health and well-being. They are widely used and accessible, making them ideal for studying pedestrian connectivity and infrastructure effectiveness in urban planning (Sugiyama *et al.*, 2018). Effective pedestrian infrastructure is crucial for enhancing the connectivity and accessibility of pedestrian pathways and routes.

The proximity of pedestrian pathways or routes from residences to parks plays a pivotal role in park usage, which emphasises the necessity for uncomplicated access that considers the mobility needs of all urban residents (Sendi and Golicnik Marusic, 2012). Furthermore, inadequate pedestrian pathways can not only hinder access to public parks but also compromise the efficiency and quality of the broader transport network (Khanyile and Fatti, 2022). The nuances of pedestrian behaviour in South Africa, characterised by prevalent jaywalking and roadway walking (Brysiewicz, 2001), signal a deeper issue with urban infrastructure that remains insufficiently explored. These behaviours indicate a potential disconnect between existing pedestrian facilities and the needs or safety perceptions of the residents. Todes *et al*. (2010) affirm walking as a primary mode of transportation across South Africa, not just in business districts but extending into residential areas as well. Yet, pedestrian safety issues, including hazardous practices and the obstruction of sidewalks by vegetation and debris, persist (Dempsey, 2012; Brysiewicz, 2001).

Beyond mere access, a pedestrian-friendly environment contributes to broader societal benefits including elevated property values, reduced environmental pollution, and enhanced social cohesion (Uysal *et al*., 2016). This is particularly relevant for developing countries like South Africa, where improving walkability could yield substantial social and economic dividends to promote the economic growth of the country (Pretorius, 2018). The perceived and actual safety of pedestrians significantly influences their willingness to use sidewalks for transportation (Jacobs, 2020), suggesting that subpar pedestrian infrastructure and safety concerns may deter residents from accessing public parks on foot (Mendzina and Vugule, 2020). This study aims to delve into the intersection of the built environment and safety perceptions, exploring how they impact pedestrian decisions at a neighbourhood level in South African cities, with Bloemfontein serving as a case study. This detailed examination seeks to contribute to the broader discourse on urban planning and pedestrian infrastructure by addressing the identified gaps in research and highlighting the importance of inclusive, safe, and accessible pedestrian networks for enhancing urban liveability and park accessibility.

This study investigates the role of residential neighbourhood sidewalks in promoting pedestrian connectivity to public parks in a residential neighbourhood in the city of Bloemfontein in South Africa. The following sections are dedicated to describing the area of the study, and a detailed discussion on the methodology employed to collect, identify the attributes, and construct the conjoint profiles.

STUDY AREA

For this paper, out of the 35 neighbourhoods in the city of Bloemfontein in South Africa, Universitas was chosen as a representative example. The neighbourhood is distinguished by its varied trip-generating destinations and status as the city's largest neighbourhood, with many pedestrians bypassing sidewalks. Universitas aptly embodies other neighbourhoods in Bloemfontein and has student residences and guesthouses scattered among the 2,000 full-title houses (Realnet Properties, 2024). Universitas is located on the south-western side of Bloemfontein; it spans an area of 9.66 km^2 with a population of 9,076 (Stats SA, 2011). The suburb includes major sub-arterial roads connecting neighbouring areas and the business district, serving as an essential passage for both motorists and pedestrians. Universitas' residents primarily inhabit stand-alone houses, apartments, and townhouses. The neighbourhood houses the University of the Free State with 37,000 students, and the increasing student population has significantly augmented resident numbers in recent years, with many houses being transformed into student accommodation. Besides students, the overall income level in Universitas varies from medium

Figure 1. Map of South Africa pinning the location of the city of Bloemfontein and the neighbourhood of Universitas (Source: Adapted from Google maps, 2024)

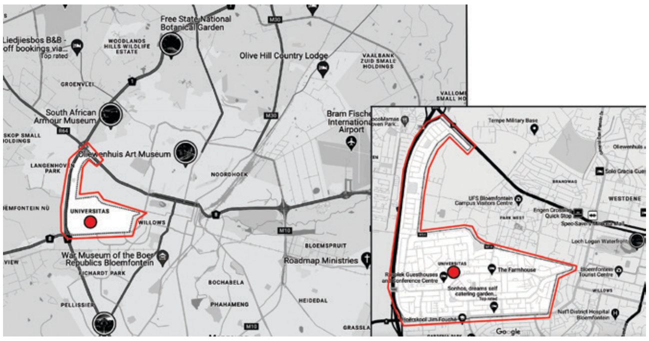

Figure 2. Close-up map of the city of Bloemfontein pinning the location of the neighbourhood of Universitas (Source: Adapted from Google maps, 2024)

to high (Figures 1 and 2 for the geographical context of the study).

As seen in Figure 3, the neighbourhood includes two primary schools (Universitas primary school and Grey college primary) and three secondary schools (i.e. Grey college secondary school, Eunice secondary school and Dr. Bohmer secondary school). Additional trip-generating destinations such as two retirement villages, a hospital five churches and two shopping centres make Universitas rich in pedestrian activity. Although the residential area of the suburb is only indicated by a red outline in Figure 2, the University of the Free State and the school's zone in the grey areas in Figure 3 are included in the overall area of the neighbourhood. The variety of land uses in this neighbourhood, as well as the surrounding amenities such as the Loch Logan waterfront, Mimosa mall, Temple military base and the residential area of Langenhoven park to the west of the suburb also generate increased thoroughfare traffic through the area.

There are a significant number of public parks within South African cities' residential zones. There are about 202 public parks in Bloemfontein that cover an area of 167 km^2, which averages 1.2 public parks per square kilometre (Honiball, 2016). Of these public parks, thirteen are located in the suburb of Universitas (Figure 3). Despite most residential areas in Bloemfontein being within a walkable distance to public parks, with Universitas being no exception, we observed their usage is surprisingly low, often seeing deserted and neglected parks (Figure 4) (Honiball, 2016). McConnachie and Shackleton (2010) explain this phenomenon by pointing out a decline in the quality and maintenance of public green spaces and inadequate provisioning. This situation is attributed partly

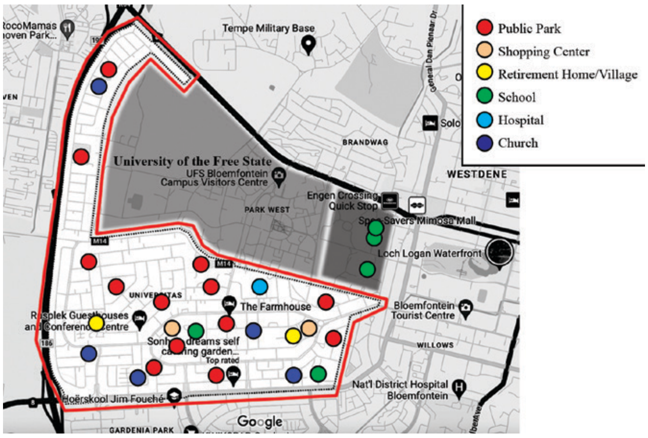

Figure 3. Mixed land use of the residential neighbourhood of Universitas (Source: Adapted from Google maps, 2024)

Figure 4. Public parks in Universitas at 1) Wynand Mouton Drive, 2) Kwarts Street, 3) Francois Retief Street and 4) Wynand Mouton Drive (Source: Google Maps, 2022)

to historical legacy issues and partly to municipal budget and resource limitations.

Universitas exemplifies the common problem of pedestrians opting for roadways over sidewalks. The authors' personal experience, field observations, and photo documentation of the neighbourhood show that pedestrians interrupt regular motorised traffic flow despite sidewalks being available, but not necessarily suitably pedestrian-friendly (Figure 5). Universitas is an ideal study area, due to its high representation of mixed land use, which includes residential homes, student accommodation, schools, and shopping centres. This diverse land use results in significant pedestrian activity, making it a representative example for examining the challenges of walkability and the common issue of pedestrians opting for roadways over sidewalks due to various obstructions (Görgün and Cubukcu, 2022). Mixed land use encompasses a variety of functional land uses, such as residential, commercial, industrial, institutional, and mobility-related purposes (Almansoub *et al.*, 2022). Roads leading to public parks in the area are lined with sidewalks. However, impediments affecting walkability pose a significant issue. Pedestrians ideally should utilise sidewalks instead of roads designated for vehicles, but various obstructions frequently push pedestrians onto the roadways. The average sidewalk width and road lane width were measured using GIS software. All road lane widths (between 3.6 m and 4.8 m) were deemed adequate for bidirectional vehicular movement, albeit hazardous when shared with pedestrians. The widths of the sidewalks in the service areas are also suitable (ranging between 3.0 m and 3.5 m) for pedestrian use, provided they are clear of obstructions. Figure 6 depicts pedestrian-unfriendly sidewalks in the study area. Key observable features in these photographs include:

- A varying state of maintenance, from acceptable to poor;
- Gardens infringing on a portion or the entirety of the sidewalk; and
- Multiple obstacles affecting pedestrian visibility and sight distance, impacting both actual safety and perceptions of safety.

Observations carried out by the authors and their research assistants also identified a range of obstructions, including trees, signboards, street lighting posts, refuse bins, garden decorations, informal stalls and electrical junction boxes, which narrow the sidewalks, affecting their walkability.

Figure 5. Pedestrians interrupting regular motorised traffic flow at 1) Weitz Street, 2) Boersma Street, 3) President Paul Kruger Avenue and 4) Wekkie Saayman Street to avoid pedestrian-unfriendly sidewalks (Google Maps, 2022)

Figure 6. Pedestrian-unfriendly sidewalks in the study area at 1) President Paul Kruger Avenue, 2) Francois Retief Street, 3) President Paul Kruger Avenue and 4) DF Malherbe Avenue (Source: Google Maps, 2022)

METHODOLOGY

Every public park in the study area was pinpointed as a trip-generating destination. A thorough physical survey was undertaken to measure all sidewalk networks and evaluate their general maintenance condition. The service area of a public park was established by measuring the walking distance from residential homes to the park using Geographic Information System (GIS) software. Typically, this was defined as a radius that can be covered within a 10 to 15-minute walk, ensuring that the park is accessible to the majority of residents within this proximity. The length of the pedestrian sidewalk network within each service area of the study area was also calculated using GIS software. The measured service area was the total length of continuous sidewalk on a stretch of road. This measurement was key in comparing the condition of the road network with that of the sidewalk network.

An approximation of the average time a pedestrian takes to reach a public park was calculated by determining the average travel distance from homes to the parks and then employing the standard walking speed for computation in Universitas. The average distance was measured by GIS taking into consideration the actual distance and shortest paths a pedestrian could take in the area. It was deduced that most inhabitants do not exceed 13 minutes in their commute from their houses to neighbourhood parks, with the shortest travel time being roughly 4 minutes. However, most of the travel times to public parks hover between 6 and 9 minutes.

Following the initial data collection phase, a household survey was conducted in residential zones across the city to further enrich the study's dataset. This survey employed a meticulously pre-tested questionnaire to ensure clarity and relevance of the questions posed. Systematic random sampling was chosen as the strategy to select participants, resulting in a total of 319 respondents. Of these, 284 responses from residents in the study areas were deemed usable and were subsequently included in the analysis. The data gathered from these surveys were processed and analysed utilising the SPSS software, specifically leveraging its Conjoint analysis capabilities. This sophisticated statistical technique enabled a deep dive into the preferences of pedestrians concerning various sidewalk attributes.

Figure 7 provides a comprehensive diagram depicting the methodology and structure used in the study. This diagram outlines the key steps, including data collection, Conjoint analysis, evaluation of sidewalk attributes, and policy recommendations, offering a clear visual representation of the research process and its systematic approach.

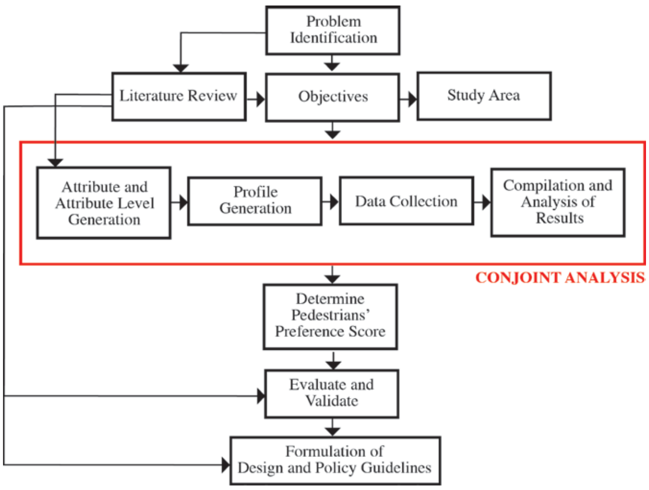

Figure 7. Diagram depicting methodology used in this study (Source: Authors, 2024)

Conjoint analysis technique

Utilising the Conjoint analysis technique provided insightful revelations about pedestrian preferences and helped in the meticulous crafting of Conjoint profiles. These profiles are essential for understanding the relative importance of different sidewalk attributes from a pedestrian's perspective, including aspects such as safety, maintenance, and the presence of obstacles. By analysing the trade-offs that pedestrians are willing to make among these attributes, the study offers valuable insights into how urban sidewalks can be optimised to enhance pedestrian satisfaction and safety. This approach not only underpins the study's empirical findings but also contributes significantly to the body of knowledge on urban planning and the development of pedestrian-friendly infrastructure.

This multivariate technique, initially developed for market research, aims to understand individual preferences (Green and Srinivasan, 1978). The Conjoint analysis technique operates based on the assumption that a person will weigh various attributes of a specific product before making a final decision.

In this research, pedestrian behaviour concerning sidewalk attributes was examined, supplying the inputs for the Conjoint analysis technique application. A recent study by Wicramasinghe and Dissanayake (2017), in which they used the Conjoint analysis technique as an unbiased method for assessing the attributes leading pedestrians to avoid sidewalks, served as a reference. This method was employed to assess sidewalk networks in residential areas, as opposed to central business districts.

The part-worth utility index was used to compute the Total utility value of selected sidewalk locations using equation (1). According to Conjoint analysis theory, a product (in this case, sidewalk profiles leading to public parks) with a higher Total utility value than others is considered more valuable (Green and Srinivasan, 1978).

$$\textbf{Total Utility Value } U(X_{ij}) = \text{Constant} + \sum_{i=1}^{m}\sum_{j=1}^{k_i} u_{ij}X_{ij} \qquad (1)$$

U(Xij) = Total utility of an alternative

m = Number of attributes

ki = Number of levels in ith attribute

uij = Utility associated with jth level of the ith attribute

Xij = Dummy variable that takes on the value 1 if the jth level of the ith attribute is present, otherwise it takes the value 0.

Generating sidewalk attributes

In developing the attribute set for the Conjoint analysis of sidewalk characteristics, a rigorous approach was taken to ensure the study's validity and integrity. The selection of attributes crucial for the analysis was guided by a comprehensive strategy that included a thorough literature review and insights gained from initial field surveys around public parks. Among the key attributes identified was the overall maintenance condition of sidewalks, highlighted in the field of urban planning for its significant impact on pedestrian choices (Wicramasinghe and Dissanayake, 2017) and pedestrian safety (Dempsey, 2012; Brysiewicz, 2001). Field observations in the study area also revealed that the presence of obstacles on sidewalks in the study area and the perception of safety among pedestrians are also attributes. The chosen attributes and their levels were designed to reflect a wide range of pedestrian experiences, aiming to cover diverse scenarios encountered by sidewalk users.

The evaluation of factors influencing pedestrian choices in sidewalk usage focused on identifying attributes critical to their preferences and safety perceptions. This process involved an in-depth analysis of existing methodologies and tools to accurately measure the impact of factors such as the state of maintenance, pedestrian safety, and the presence of obstacles on sidewalk accessibility. Special attention was given to the pedestrians' perceived safety, acknowledging its profound effect on sidewalk selection. This comprehensive approach ensures that the analysis accurately reflects the multifaceted nature of pedestrian preferences and the complexities involved in sidewalk utilisation.

Data collection

The data collection for this study was conducted using two principal methodologies: a detailed questionnaire distributed to residents in the targeted area, and a series of observational counts of park users conducted monthly. By combining these approaches with insights from existing research, the study gained a layered perspective on the reasons pedestrians might choose to avoid certain sidewalks. From this multifaceted analysis, four primary attributes emerged as significant: pedestrian safety, the presence of obstacles on sidewalks, the perception of safety among pedestrians, and the general condition of sidewalk maintenance. These attributes were categorised into three distinct levels of impact, as outlined in Table 1, allowing for a nuanced and structured evaluation.

Table 1. Selected sidewalk attributes and their different assigned levels of influence

Sidewalk attribute	Different Levels		
	Level 1	**Level 2**	**Level 3**
Pedestrian safety	Safe	Relatively Safe	Unsafe
Number of obstacles on sidewalks	0	1-5	>5
Perception of safety	Perceived safe	Perceived relatively safe	Perceived unsafe
Maintained condition of sidewalks	Good	Acceptable	Bad

This rigorous definition and classification of attributes underpin the study's commitment to producing reliable, unbiased results that can significantly inform urban planning and pedestrian infrastructure improvement efforts. By ensuring the comprehensiveness and clarity of each attribute, the research aims to contribute meaningful insights into how neighbourhood sidewalks can promote accessibility to public parks in a suburb of Bloemfontein in South Africa.

DATA ANALYSIS, INTERPRETATION AND FINDINGS

In the application of the Conjoint analysis technique, selected attributes must be combined into sets of hypothetical profiles. A total of 81 (3x3x3x3=81) attribute combinations are possible. However, these combinations can be reduced to a more manageable nine profiles through a statistical method known as orthogonal fractional design. This method is essential, since the Conjoint analysis technique employs a ranking response technique, which could become overly demanding for respondents if they were asked to rank 81 profiles rather than a simpler set of nine.

The orthogonal fractional design is a method used to diminish the number of profile configurations, while ensuring all attributes are represented equally and without correlation. This design was implemented using the Statistical Package for the Social Sciences (SPSS) software. Table 2 depicts the nine profiles generated by applying the orthogonal fractional design to the attribute profiles.

Table 2. Nine hypothetical profiles generated using orthogonal fractional design

Card	Pedestrian safety	Number of obstacles on sidewalks	Perception of safety	Maintained condition of sidewalks
1	Unsafe	1 - 5 obstacles	Perceived unsafe	Good
2	Unsafe	> 5 obstacles	Perceived safe	Acceptable
3	Relatively safe	No obstacles	Perceived unsafe	Acceptable
4	Relatively safe	> 5 obstacles	Perceived relatively safe	Good
5	Relatively safe	1 - 5 obstacles	Perceived safe	Bad
6	Safe	> 5 obstacles	Perceived unsafe	Bad
7	Safe	No obstacles	Perceived safe	Good
8	Unsafe	No obstacles	Perceived relatively safe	Bad
9	Safe	1 - 5 obstacles	Perceived relatively safe	Acceptable

Each hypothetical profile was subsequently rendered into illustrative form for the respondents to rank. Great care was taken to maintain uniformity across each profile to minimise the impact of any factors beyond the attributes being evaluated. Once the nine representative profiles were illustrated, they were included in a portion of the questionnaire for respondents to rank from 1 (most preferred) to 9 (least preferred).

In conducting the Conjoint Analysis, a model that anticipates the relationship between attributes and ranking scores is required. For this analysis, a discrete relationship is assumed between factors and ranking scores. As depicted in Figure 8, a discrete model suggests that the attribute levels are categorical, with no assumption made regarding the relationship between the attributes and the ranks.

The Conjoint Analysis yields the relative importance of each attribute. Each attribute is assigned an importance value, indicating its significance relative to other attributes. The importance of an attribute is derived from the degree of difference that each attribute contributes to the total utility of a given profile. The utility values of the attributes arise from the range of level differences among the attributes. The Importance Level depends on the specific attribute levels chosen for the evaluation. For instance, the wider the range, the more significant the attribute. The importance measures are ratio-scaled, relative, and study-specific. Therefore, an attribute with an importance of 40% is twice as important as an attribute with an importance of 20%. Figure 8 illustrates how the importance of an attribute is determined.

The evaluation of the chosen attributes revealed that pedestrian safety has the highest importance value of 51.5%. The number of obstacles followed with an importance value of 33.5%. perception of safety achieved an importance value of 9.8%, while the maintained condition of sidewalks scored a 5.2% value of importance.

When it comes to the use of sidewalks leading to public parks, pedestrian safety was found to be the most critical

Attribute	Level	Part-worth utility	Attribute utility range	Attribute importance
1	A	Min	Max-Min=Range 1	(Range/Utility Range) x 100 = Importance of 1
	B	Max		
	C	Mid		
2	A	Min	Max-Min=Range 2	(Range/Utility Range) x 100 = Importance of 2
	B	Max		
	C	Mid		
3	A	Min	Max-Min=Range 3	(Range/Utility Range) x 100 = Importance of 3
	B	Max		
	C	Mid		
				Utility Range Total Range 1 + Range 2 + Range 3 = Utility Range

Figure 8. Determination of attribute importance
(Source: Green and Srinivasan, 1978)

attribute. The second most important attribute was the number of obstacles on the sidewalks. The perception of safety was seen to be five times less significant than actual pedestrian safety, possibly due to residents' familiarity with their residential area. The maintained condition of the sidewalks turned out to be the least significant attribute.

However, the interpretation of part-worth utilities hinges on a clear understanding of the importance of each attribute. Part-worth utilities allow for a deeper understanding of the specific features within an attribute that influence a respondent's choice. They are numerical values assigned to each attribute level, reflecting the degree to which each attribute and level influenced the respondents' decisions. Preferred attribute levels receive higher scores, while less preferred ones receive lower scores. Nonetheless, it is vital to note that these part-worth values are relative. A negative utility value for an attribute level does not imply that the attribute level was undesirable. In fact, an attribute level with a negative value could have been accepted by all respondents. However, other things being equal, a more positive value is preferable.

Part-worth utilities in the Conjoint analysis technique are scaled to an arbitrary additive constant within each attribute and are interval data. Thus, utilities are scaled to sum to zero within each attribute. The results for the relative and individual part-worth utilities are summarised in Table 3.

Table 3. Conjoint analysis results: Part-worth utilities

Part-worth utilities		
Attributes	**Attribute levels**	**Utility estimate**
Pedestrian safety	Safe	1.400
	Relatively safe	-.008
	Unsafe	-1.352
Number of obstacles	No obstacles	1.204
	1 - 5 obstacles	-.434
	> 5 obstacles	-.780
Perception of safety	Perceived safe	-.200
	Perceived relatively safe	.345
	Perceived unsafe	-.165
Maintained condition	Good	.132
	Acceptable	-.123
	Bad	-.014
(Constant)		5.000

What is noticeable in Table 3 is the range of pedestrian safety. Sidewalks that are considered safe are much more preferred than sidewalks perceived as unsafe. This underscores the importance of this attribute, as mentioned before. Another observation is that the pedestrian safety attribute levels appear to have a logical and relative linear relationship. The number of obstacles on the sidewalk is the attribute with the second-highest importance. The attribute levels show a logical increase in importance, with more than five obstacles being the least important, followed by one to five obstacles, and then no obstacles. In relation to the other attributes and their attribute levels, having no obstacles was found to be the second most important attribute level.

The results regarding the perception of safety may seem initially counterintuitive, with the "relatively safe" perception of safety receiving a higher preference score than the "safe" perception. Interestingly, the "unsafe" perception of safety also has a marginally higher value than the "safe" perception. The main reason for this can be traced back to the nature of the conjoint-generated profiles. These profiles are designed to represent all attribute levels equally and uncorrelated, leading to combinations of attribute levels that compel the respondent to prioritise the most preferred attributes, even at the expense of others deemed less important.

Similarly, a poorly maintained sidewalk has a lower preference score than a sidewalk in an acceptable state of maintenance. This too can be attributed to the combinations of attributes in the conjoint-generated profiles, as discussed earlier. The part-worth utilities for the maintenance conditions of the sidewalks leading to public parks are very low, therefore contributing little to the calculation of Total utility values (TUV).

Moreover, after assigning appropriate attribute levels at each location, the Total utility value of all eleven locations was calculated (Table 5). Table 4 provides an example of how the Total utility value is calculated at location 8.

The disparity between the TUV of different sidewalk locations highlights the significant role of safety and condition in pedestrian preference. Locations with higher TUV, indicating higher overall utility for pedestrians, possess key attributes such as safety, the absence of obstructions, and good maintenance, which are deemed most desirable by pedestrians. Conversely, those locations with lower TUV have unfavourable attributes, particularly pertaining to safety, making them less attractive to potential users.

By comparing the TUV with the actual usage data of each public park, policymakers can determine whether sidewalks' attributes align with their usage. If a park with high actual usage has a sidewalk with low TUV, this could indicate a pressing need for improvements to the sidewalk's safety, maintenance, and removal of obstructions. Conversely, if a park with low usage has a sidewalk with a high TUV, this might suggest that other factors, not related to the sidewalk, are affecting the park's usage, which warrants further investigation.

The insights from the Conjoint analysis and TUV can guide urban planners and local authorities in decision-making regarding urban infrastructure improvements. By understanding pedestrians' preferences, they can make informed decisions to enhance the sidewalks' conditions leading to public parks, promoting their use and contributing to more walkable streets, with active, and healthy communities.

Table 4. Example of calculating Total utility value at a location

Attribute	Applicable attribute level	Part-worth utility	Sum	Conjoint constant	Total utility value
Pedestrian safety	Safe	1.40	2.39	+ 5	= 7.39
Number of obstacles	None	1.20			
Perception of safety	Perceived relatively safe	-0.20			
Maintained condition	Good	-0.01			

Table 5. Attribute levels and Total utility value of each selected location

Location	Pedestrian safety		Number of obstacles		Perception of safety		Maintained condition		Constant	Total utility value
1	Relatively safe	-0.01	> 5	-0.78	Perceived unsafe	-0.16	Acceptable	-0.12	5	3.92
2	Relatively safe	-0.01	1 – 5	-0.43	Perceived unsafe	-0.16	Good	-0.01	5	4.38
3	Safe	1.40	> 5	-0.78	Perceived relatively safe	0.34	Acceptable	-0.12	5	5.84
4	Safe	1.40	1 – 5	-0.43	Perceived safe	-0.18	Acceptable	-0.12	5	5.64
5	Safe	1.40	> 5	-0.78	Perceived unsafe	-0.16	Acceptable	-0.12	5	5.33
6	Relatively safe	-0.01	> 5	-0.78	Perceived relatively safe	0.34	Acceptable	-0.12	5	4.43
7	Unsafe	-1.35	1 - 5	-0.43	30% Perceived relatively safe 70% Perceived unsafe	-0.02	Good	-0.01	5	3.19
8	Safe	1.40	None	1.20	Perceived safe	-0.20	Good	-0.01	5	7.39
9	Unsafe	-1.35	1 – 5	-0.43	Perceived relatively safe	0.34	Good	-0.01	5	3.55
10	Safe	1.40	1 – 5	-0.43	40% Perceived safe 60% Perceived relatively safe	0.13	Good	-0.01	5	6.08
11	Unsafe	-1.35	1 – 5	-0.43	Perceived unsafe	-0.16	Acceptable	-0.12	5	2.93

DISCUSSION

Interpretation of results in relation to existing literature

The findings from the Conjoint analysis provide significant insights into the attributes influencing pedestrian usage of sidewalks in residential neighbourhoods. The study revealed that pedestrian safety is the most critical factor, followed by the number of obstacles on the sidewalks. These findings align with existing literature which emphasises the importance of safety in pedestrian infrastructure. For instance, Das and Honiball (2016) highlight that safety concerns are a major deterrent for pedestrians, which is echoed by Mendzina and Vugule (2020), who state that perceived and actual safety significantly influence pedestrian behaviour.

The second most important attribute identified was the number of obstacles on sidewalks. This supports the findings of Brysiewicz (2001), who pointed out that obstructions such as vegetation, debris, and other obstacles can severely impede pedestrian movement and safety. This study adds to the body of literature by quantifying the impact of these obstacles and demonstrating their relative importance through Conjoint analysis.

Interestingly, the perception of safety was found to be less significant compared to actual safety and the number of obstacles. This result suggests that residents may have adapted to their environment, relying more on tangible safety measures rather than their perceptions. This finding contrasts with some studies, such as those by Dempsey (2012), which argue that perceived safety is often as important as actual safety. However, the unique context of South African residential neighbourhoods, characterised by distinct socio-political and urban dynamics, may account for this discrepancy.

The least important attribute was the maintained condition of sidewalks, which, while still relevant, was not as critical as the other factors. This finding suggests that while maintenance is important, it is secondary to ensuring safety and removing obstacles. This is in line with studies by Wicramasinghe and Dissanayake (2017), which indicate that maintenance alone cannot significantly improve walkability without addressing safety and obstruction issues.

Policy recommendations

Based on the findings, several policy recommendations can be proposed to enhance pedestrian connectivity to public parks:

- **Infrastructure upgrades:** Prioritise the repair and maintenance of existing sidewalks, ensuring they are free from obstructions such as overgrown vegetation and construction debris. Well-maintained pathways are crucial to encourage walking as a mode of transportation.

- **Enhanced connectivity:** Urban planners should create a network of sidewalks that seamlessly connects residential areas to public parks. This involves identifying and bridging gaps in the current pedestrian network to ensure that residents have direct and uninterrupted pathways to parks and other essential amenities.
- **Safety measures:** Introduce well-lit sidewalks, crosswalks, pedestrian signals, and protective barriers to address safety concerns. Improved visibility during both day and night can significantly enhance the perceived sense of safety for pedestrians.
- **Accessibility for all:** Design sidewalks that cater to people of all ages and abilities. This includes the introduction of ramps for wheelchair users, tactile paving for the visually impaired, and safe crossings for children and older adults.
- **Public awareness:** Launch community awareness campaigns about the benefits of walking, both for health and the environment. Engaging with local communities can also provide insights into specific areas of concern and potential solutions.
- **Regular review:** Conduct periodic reviews using techniques like Conjoint Analysis to monitor and understand changing preferences and challenges faced by pedestrians. This adaptive approach ensures that urban planning remains responsive to the evolving needs of the city's residents.

CONCLUSION

This paper contributes to the growing body of literature highlighting the importance of accessible pedestrian infrastructure that is fit for purpose to improve community life in residential neighbourhoods, foster healthier and more active lifestyles, and create inclusive sustainable urban environments. Accessibility to such urban environments, including public parks, requires a connected pedestrian infrastructure (such as sidewalks) to promote walkability. This paper aimed to analyse the functionality of sidewalks in the residential suburb of Universitas in the city of Bloemfontein in South Africa as non-motorised transportation routes. This phenomenon was investigated using a Conjoint analysis technique which was found to be a powerful tool in urban planning to provide valuable insights into pedestrian preferences in the study area. The research method pinpointed the physical layout, as well as the perceived and actual safety of pedestrians, as the primary factors impacting sidewalk usage in the study area. Furthermore, this paper intended to illuminate factors to enhance the utility and attractiveness of public spaces in residential areas that urban planners and policymakers could consider. The findings suggested that infrastructure upgrades, connected sidewalks and public parks, safety measures, inclusive design, community awareness programmes, and periodic reviews of the needs of pedestrians could lead to cities that promote active lifestyles and become more inclusive, sustainable, and conducive to holistic well-being.

Future studies might consider other factors related to urban planning and infrastructure, such as the standard of public transportation, the presence of cycle lanes, and the proximity of amenities such as shops and schools. These factors are likely to interact with the quality of sidewalks to shape the travel behaviour of urban residents, and a more comprehensive understanding of these relationships could contribute to more effective urban planning and policymaking. Furthermore, an integrated approach to urban design is essential for cities aiming to be sustainable and inclusive, by exploring how well-run public transportation systems may lessen dependency on personal automobiles, how cycle lanes encourage environmentally friendly transportation, and how the proximity of facilities affects people's mobility.

As with any research, there are limitations that need to be noted. A major limitation is the research scope, which focused on only one suburb in the city of Bloemfontein. This may counter the generalizability of the study's findings to other areas as well as the relevancy of the four primary attributes (pedestrian safety, the presence of obstacles on sidewalks, the perception of safety among pedestrians, and the general condition of sidewalk maintenance) that emerged. Lastly, the research design and methodology adopted in this paper offers a specific stance of investigating the phenomena, which may be enriched with other research approaches such as ethnography, phenomenology or participatory placemaking.

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