




Travel mode choices of residents in developing cities: A case study of Lusaka, Zambia

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Background: As urban populations rapidly expand across sub-Saharan Africa, promoting sustainable and efficient transportation systems is imperative for fostering economic growth and social inclusion by enhancing mobility and accessibility.

Objectives: This study examines the travel mode choices and factors influencing the use of these modes among residents of Lusaka, Zambia, for their work or school trips.

Method: A household survey ascertained mode choice, trip characteristics, and transportation challenges experienced. Descriptive, contingency table, and post hoc analyses explored relationships between mode and associated factors.

Results: Public buses emerged as the predominant mode for work/school trips, followed by walking and private cars, highlighting public transit's and non-motorised transport's importance. However, travel behaviour varied significantly by residential density. High-density areas favoured public transit and walking, while low-density areas promoted greater private vehicle use, highlighting the influence of urban form on mode choice. Key mode choice factors included travel time, fares and safety, though environmental concerns had lesser impact. Crucially, socio-economic and demographic characteristics like age, gender, income, education, employment, car ownership, trip purpose, household composition, presence of children, and destination accessibility significantly influenced mode choices, revealing the complex interplay shaping mobility patterns.

Conclusion: Findings underscore the need for policy interventions investing in public transportation infrastructure, enhancing pedestrian and cycling facilities, and prioritising walkability in urban planning to encourage sustainable transportation behaviours.

Contribution: This study contributes to the discourse on urban sustainability by highlighting the importance of integrating social, economic, and environmental considerations into transportation planning and policymaking processes.

Keywords: travel behaviour; travel mode share; mode selection; sustainable transportation; commuting trips; developing cities.

Introduction

Transport networks are essential for the growth of any economy or society as they connect people to jobs, schools, hospitals, and to other social activities. However, transportation accounts for approximately 64% of global oil consumption, 27% of overall energy consumption, and 23% of global energy-related carbon dioxide (CO₂) emissions (Mead 2021). Globally, motor vehicle pollution is directly responsible for over 185 000 deaths, while road traffic crashes kill an estimated 1.3 million people annually (WHO 2018). Consequently, addressing urban transport challenges is of utmost importance to promote the sustainable growth of cities, balancing the need for connectivity with environmental and public health considerations.

The choice of a transport mode is one of the most essential aspects of urban transport planning and policy as it impacts the overall efficiency with which residents can travel in urban areas (Duleba, Moslem & Esztergár-Kiss 2021; Ort'uzar & Willumsen 2011). Travel mode share or mode split is defined as the proportion of people using a particular mode of transport and is typically presented as a percentage of each mode (McCann 2015). It can be based on a variety of factors, such as the proportion of travellers using a certain mode of transportation, the percentage of trips taken or the distance travelled using a particular mode of transportation (Fountas et al. 2020).

Many developing cities are experiencing a rapid and unplanned growth, which is placing tremendous strain on their transport systems (Mwale, Luke & Pisa 2022). In recent decades,

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developing cities have experienced high rates of motorisation, and this trend is expected to continue in the future (Thondoo et al. 2020). Predictions estimate that the number of vehicles will increase three- or four-fold, especially in developing nations, between 2005 and 2050 (Mead 2021). The environmental and social impacts of growing motorisation are significant and directly related to quality of life and urban productivity.

Lusaka's passenger transit system comprises a mix of private vehicles, public buses, taxis, motorcycles, and bicycles. Specifically, the public transport network in Lusaka includes minibuses, buses, and taxis. Minibuses, ubiquitous in the city, accommodate 12–15 passengers along predefined routes, while larger 25–30 seater buses serve designated city routes (Ngoma & Phiri 2016). The determination of bus routes for both minibuses and buses is influenced by a combination of supply and demand dynamics, as well as the presence of sufficient transport infrastructure. Taxis offer personalised travel and comfort for 3–4 passengers, although overcrowding is possible in larger vehicles. These taxis can be licensed, metred vehicles operated by registered companies or unlicensed, informally run taxis using private cars. The popularity of ride-hailing taxi services has soared because of their transparent pricing and convenience. Notably, unlike many other African cities, motorbikes are not widely utilised for public transport in Lusaka (Krasholucka 2022).

The transport environment in the city is fraught with various problems such as the use of shared road space by mixed-modes, traffic congestion, road traffic crashes, poor road infrastructure, and inadequate enforcement of traffic regulations (GRZ 2019a). Formalised public bus services frequently lack reliability, comfort, and safety, thereby failing to adequately meet the transportation requirements of residents (Chikuba 2014): a situation that has led to a rise in the informal or paratransit services, which often lack consistency and safety features (Pojani & Stead 2015). Furthermore, the continued horizontal growth, or urban sprawl, of Lusaka city, is becoming a major cause of the increase in travel distances (Mahendra & Karen 2019). This phenomenon discourages people from utilising non-motorised transport modes such as walking and cycling and has resulted in an increased demand for public transport services as well as private motorised transport (Kakar & Prasad 2020). To deal with the growing problem of traffic congestion, city authorities in Lusaka have embarked on massive road infrastructure improvement projects, which include the expansion of existing roads and the construction of flyovers (Mutumweno 2021). However, the development of transport infrastructure that prioritises the use of motor vehicles leaves very little room for the introduction of alternative modes that tend to reduce the share of other modes of transport (Litman 2011).

In light of the rapid urbanisation and increasing mobility challenges faced by cities in the Global South, understanding travel mode preferences and the factors influencing them

in Lusaka, Zambia, becomes crucial. This study examines the travel mode choices and factors influencing the use of these modes among residents of Lusaka for their work or school trips. Additionally, it aims to explore the key challenges faced by users of each travel mode. This research contributes to the existing body of literature by offering unique insights into the travel behaviours and decision-making patterns of Lusaka's urban dwellers. This study aims to contribute valuable insights into transportation in African cities, aiding the formulation of context-specific and sustainable urban mobility policies. Understanding the travel behaviours and decision-making patterns of city residents is crucial for effective urban planning and transportation management. By gaining unique insights into how people move within the city, policymakers can tailor transportation infrastructure, services, and policies to better meet the needs of residents. This can lead to improved mobility, reduced congestion, enhanced access to opportunities, and ultimately, a more liveable and sustainable urban environment.

Literature review

Transportation plays a vital role in the development and functioning of urban areas, particularly in cities in low- and middle-income countries (LMICs) where challenges related to mobility and accessibility are prevalent. The understanding of travel mode share and mode selection among residents is essential for sustainable urban planning and the formulation of effective transportation policies (ITF 2021). Within the context of cities in sub-Saharan Africa (SSA) such as Lusaka, rapid population growth, unplanned urbanisation, and inadequate infrastructure are salient issues. These challenges directly impact transportation systems, leading to further problems including traffic congestion, environmental pollution, a heavy reliance on informal mobility, and poor road safety (Palanivel 2017; Pojani & Stead 2015; World Bank 2022; Mwale et al. 2023). The lack of sufficient and effective transportation infrastructure intensifies these problems, leading to safety hazards alongside the exacerbation of congestion and pollution. Public transportation systems are often ill-equipped to support the needs of burgeoning populations, which fuels congestion and environmental degradation (National Academies of Sciences Engineering, and Medicine 2018).

Expanding on specific transportation challenges, traffic congestion emerges as a significant challenge, with roots traceable to the fast pace of population growth, insufficient infrastructure, and ineffective traffic regulation (Karimi et al. 2022). Specifically, in cities in SSA, such congestion can cause extended travel delays, increase pollution levels, and can impede productivity (Agyapong & Ojo 2018). Escalating air pollution levels lead to the deterioration of air quality and the contamination of water bodies. Additionally, noise pollution, often a by-product of intensive traffic flow, is another environmental problem, causing its own range of health issues and further complicating the challenges faced by urban areas (Moroe & Mabaso 2022). Lusaka, for instance,

grapples with air pollution emanating from vehicles and water pollution resulting from inadequate drainage and sewer systems (Mbuzi 2020).

Urban expansion places immense pressure on the already strained infrastructure in developing cities, while informal settlements often lack necessary amenities (Chiwele Lamson-Hall & Shahrukh 2022; Mwamba 2020). Concurrently, the city's public transportation system is marred by overcrowding and unreliability (Transaid 2021). Overcrowded buses and unreliable services create a daily struggle for residents, impacting their comfort, time management, and overall urban mobility. Residents primarily resort to walking, cycling, and public transportation for their commuting needs (Tucho 2022). Road safety is a significant issue in cities within developing countries. Lusaka, reflecting challenges in other rapidly urbanising areas of the Global South, faces alarming rates of road traffic fatalities and injuries. In 2021, Zambia reported a total of 32 372 traffic crashes and 2163 deaths, with Lusaka province accounting for 55% of crashes (13 774 incidents) and 28% of total fatalities (516 deaths) (Mwale et al. 2023; RTSA 2022). These alarming proportions demand urgent actions to enhance road safety in Lusaka and reduce preventable casualties.

In exploring travel behaviour and mode choice, various theories and concepts have been proposed to explain the decision-making process behind individuals' choice of transportation modes. The Theory of Planned Behaviour (TPB) suggests that an individual's intention to use a particular mode is influenced by their attitudes, subjective norms, and perceived behavioural control (Bamberg, Ajzen, & Schmidt 2003; Othmane & Maria-del-Mar 2019). The TPB proposes that positive attitudes, perceived social approval (subjective norms), and a high degree of perceived control over performing the behaviour lead to stronger intentions and increase the likelihood of engaging in that behaviour. This study aims to understand: What factors influence the travel mode choices of Lusaka residents for their work or school commutes, and how do these choices reflect underlying psychological drivers? The TPB provides a framework to explore this research question by examining the attitudes, subjective norms, and perceived behavioural control that underlie Lusaka residents' transportation decisions. By employing the TPB, the study moves beyond demographic correlations to uncover the psychological motivations and barriers that shape commuting behaviour. This theoretical grounding offers valuable insights for encouraging sustainable transportation through interventions that address attitudes, social norms, and perceived control over travel modes.

Numerous studies have been conducted to understand the determinants of mode choice in urban settings. The selection of travel modes in urban settings exhibits notable disparities between developed and developing cities. Well-established public transportation systems, featuring buses, trains, and subways, characterise densely populated developed cities.

These urban environments prioritise sustainable modes such as walking and cycling, facilitated by mixed land use and pedestrian friendly infrastructure (Rode et al. 2017). In sharp contrast, developing cities confront challenges such as traffic congestion fuelled by rapid motorisation, urban sprawl, and underdeveloped road systems. In these contexts, private vehicles, particularly motorbikes and minibuses, dominate the transportation landscape (Agyapong & Ojo 2018; Karimi et al. 2022). Despite both types of cities facing intricate mobility challenges, the nuances of their individual contexts play a pivotal role in shaping distinct travel mode preferences and policy approaches.

In exploring the intricate interplay of demographic and socio-economic factors on travel mode choice, several studies have emphasised the role of variables such as age, gender, income, and education (Li et al. 2015; Mayo & Taboada 2020; Patil, Basu & Rashidi 2020). Research indicates a gender-based pattern in travel choices with women generally preferring more environment friendly options such as walking and public transport, while men are more inclined to use private transport (Abdullah et al. 2022; Goel et al. 2023; Saigal, Vaish & Rao 2021).

However, females also show a significant preference for private cars over cycling (Ye et al. 2020). This can be attributed to safety concerns, social norms, inadequate infrastructure, time constraints, cultural influences, and marketing efforts. Age also influences these choices, notably affecting preferences for private cars and bikes (Ye et al. 2020). These findings highlight the complexity of travel mode choices, influenced by both gender and age. Household characteristics such as income, size, and number of vehicles owned can also significantly affect travel behaviour and mode choice (McCarthy et al. 2017; Taofiki, Adebukola & Olufemi 2018). Households with young children tend to use cars more, while those without children are more likely to use public transportation (Ye et al. 2018). Several studies also show that accessibility and availability of transportation modes can critically influence travel mode choice (Christiansen et al. 2017; Singh & Vasudevan 2018; Witchayaphong et al. 2020). An absence of a public transit system or poor-quality services can cause a reliance on other motorised modes.

Apart from demographic and socio-economic factors, travel-specific factors such as distance and time have been found to significantly influence mode choice (Li & Zhao 2015; Patil et al. 2020). For obligatory trips such as work or school, public transit is preferable for its economic benefits. During situations like the coronavirus disease 2019 (COVID-19) pandemic, health implications may cause a shift from public transport to private cars (Aderibigbe & Gumbo 2022). Researchers have found that affordability and availability of public transport can attract ridership (Lekshmi, Landge & Kumar 2016; Minal & Sekhar 2014). Higher income and education levels tend to associate with greater use of private cars, while lower income and education levels correspond to more reliance on public transport and paratransit modes. Factors such as gender, residential selection, household size, presence of children,

income, travel distances, and employment status influence car use and ownership (Mwale et al. 2022). Vehicle ownership increases with higher income, employment, and education levels (Dissanayake & Morikawa 2010). In addition, there is a negative correlation between age and stop frequency, which refers to the number of stops or destinations a traveller visits during a specific journey or trip (Guan, Srinivasan & Nielsen 2019). The mode choice for travel in developing countries, particularly for work and school trips, hinges on an interplay of social demographic factors, the availability and accessibility of transport modes, and specifics of the travel. Recognising these relationships is crucial in shaping equitable and efficient transportation policies.

Drawing from the literature review, three key hypotheses emerge regarding travel mode preferences and behaviours in LMICs. Firstly, socioeconomic factors such as age, gender, income, and education are anticipated to exert significant influence, with higher socioeconomic status potentially correlating with increased private car usage. Secondly, the accessibility and availability of transportation modes, particularly public transit, and non-motorised options, are expected to shape residents' travel behaviours, with inadequate infrastructure possibly leading to greater reliance on motorised transportation. Thirdly, policy interventions targeting public transportation infrastructure, pedestrian and/or cycling facilities, and walkability are anticipated to positively impact sustainable transportation behaviours, potentially shifting preferences towards more environmentally friendly options. These hypotheses provide a foundation for understanding the complexities of travel mode choice in Lusaka's urban context and highlight the importance of socioeconomic, infrastructural, and policy factors in shaping transportation behaviour.

Despite the breadth of existing research, notable gaps persist in our comprehension of travel mode share and mode selection within cities in SSA, underscoring the necessity for deeper exploration. A limited number of studies have specifically delved into mode share and determinants of mode selection in SSA cities, underscoring the imperative for expanded research to understand the distinct intricacies of travel behaviour within these contexts. These gaps notably encompass the need for a more comprehensive examination of transportation modes, particularly non-motorised transport (NMT) and public transport modes. Furthermore, there is a need for a more comprehensive analysis of the factors influencing mode choice decisions and the effectiveness of policy interventions in promoting sustainable transportation in Lusaka.

This study conducts a detailed examination of travel mode selection among Lusaka's residents. It offers insights into demographic, socioeconomic, and trip-making characteristics, and their influence on travel behaviour. The study also reports on the mode share proportion for each transportation option, providing a clear perspective on current trends and potentially informing future policy interventions for sustainable transportation in Lusaka.

Data and methods

Study area and sampling strategy

The study was carried out in Lusaka, the capital and largest city of Zambia, with a population of 2 946 566 according to the 2010 census projections (Central Statistical Office of Zambia 2014). Lusaka district is subdivided into 33 wards for administrative purposes. To ensure a comprehensive representation, the survey employed a three-stage sampling process, stratifying the wards into low, medium, and high density based on their size in square metres and population. Figure 1 displays a map of Lusaka District, highlighting the selected wards classified by residential density.

Typically, low-density areas in Lusaka are characterised by residents with higher incomes, while high-density areas are home to individuals from the lower income bracket (Chibuye 2014). A sampling frame for Lusaka, comprising households from the 2010 census data (CSO 2014), was obtained from the Zambia Statistics Agency. To ensure sample representativeness two (2) wards were randomly selected from each density stratum. Furthermore, each ward was divided into Enumeration Areas (EAs), and two EAs were randomly selected from each ward. Households within each EA were selected using systematic random sampling. This sampling strategy was designed to capture a representative sample of Lusaka's population across various socio-economic strata and geographical locations, providing a balanced picture of mode share for home-to-work trips in the city.

During the data collection phase, household heads in each EA were approached and asked to participate in the survey. The number of households approached in each EA was determined by the number of households present in that EA. Data collection took place from 02 May 2022 to 14 May 2022.

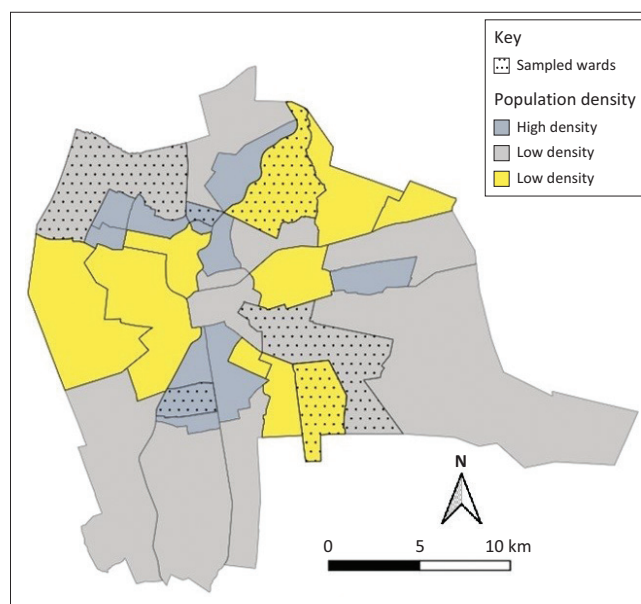


FIGURE 1: Wards in Lusaka district by population density.

The sample size was calculated using Cochran's formula for sample size determination in a large population (Cochran 1977). Given a population size of 2 900 000, a confidence level of 95%, and a margin of error of 5%, the required sample size was computed to be 385 households. However, not all sampled households responded to the survey, and the final responses totalled 268 completed questionnaires, resulting in a response rate of 70%. The reduced sample size was assessed for reliability and validity. The internal validity of the questionnaire was determined through a pilot study with a separate sample of 30 households, which was not included in the final sample. These pilot study results were not added to the final study because some refinements and changes were made to the final data collection tools, which made the results from the pilot study not directly comparable to the data collected in the main study.

Questionnaire and survey design

A survey was designed to explore people's travel mode choices, social demographic characteristics, reasons for selecting a particular mode, and challenges faced. The questionnaire was composed of 13 sections and included a total of 77 questions. These questions utilised a variety of formats such as single-answer multiple choice, matrix-style queries, open-ended responses, Likert scale evaluations, and stated choice questions, all designed to effectively capture respondents' intentions and future behaviour. On average, participants took 23 min to complete the survey. The survey was structured as follows:

- information about the user's personal and household travel details and recent trip
- information on the individual's travel behaviour and habits, including use of ride hailing services, and the factors that affect mode selection, and major challenges faced
- demographic information including employment, education, age, gender, family size, income, driver's license status, and automobile accessibility.

The survey was conducted using the online tool SurveyEngine GmbH, which ensured data security and privacy through secure connections, encrypted data transmission, and restricted access levels. Trained enumerators administered the survey face-to-face using tablets.

Data analysis

To gain insights into the data and identify patterns, trends, or anomalies, a comprehensive descriptive analysis was conducted using the R programming language. Visualisations, charts, and summary measures were generated using Microsoft Excel to better understand the distribution of variables and explore the relationship between travel mode and related factors.

Contingency table analysis was performed in R to examine the association between travel mode and related factors using a Chi-square test of independence. A significance

level of 0.05 (5%) was applied to determine if there was a statistically significant relationship between the variables. To further investigate the significant associations detected by the Chi-square test, post hoc analysis was conducted using adjusted standardised residuals. This additional analysis helped to identify specific variables that contributed to the significant association, providing more detailed insights into the relationship between travel mode and related factors. Residuals greater than 2 or less than -2 indicate a significant difference between the observed and expected frequencies, suggesting that there may be an association between the variables being analysed.

Ethical considerations

Ethical clearance to conduct this study was obtained from the University of Johannesburg, CBE Research Ethics Committee (No. 2020TSCM-0002).

Results

Descriptive analysis

Sample characteristics

Table 1 provides a comparative analysis of our sample's demographic characteristics with the Lusaka district's broader population data, sourced from the 2018 Zambia Demographic Health Survey (GRZ 2018). The comparison reveals similarities and differences in gender distribution, age distribution, education level, and household size. For instance, the sample population exhibits a slightly higher percentage of males compared to females, which mirrors the gender distribution in Lusaka. However, there are notable disparities in age distribution, with the sample showing higher proportions in the age groups of 20 years or less and 21 to 30 years, while lower proportions are observed in older age categories. Similarly, variations are observed in education levels and household size. This comparison highlights the representativeness of the sample population and underscores the need to consider demographic factors when interpreting the study findings. Overall, the sample distribution serves as a critical reference point for understanding the generalisability of the study results to the broader population of Lusaka.

Figure 2 presents the demographic characteristics of the residents surveyed categorised by the travel mode selected for their daily commute. Out of the total 268 respondents, 50% were male and 50% were female. The age group between 21 and 30 years constituted the largest proportion of respondents, while those aged above 61 years were the least represented. Regarding educational attainment, the majority of respondents had completed secondary education, followed by lower secondary education. Only a small percentage of respondents held a master's or PhD degree, while a notable proportion had not pursued formal schooling.

Regarding employment, 32% of respondents were employed full-time, 12% part-time, 23% were in education, and 18%

were unemployed. Household characteristics revealed that 28% of respondents owned a car, 76% lived with children, and 84% resided within walking or cycling distance to their place of employment or school. The most common modes of transportation used by respondents included public buses, walking, and private cars. Car availability in households indicated that 72% of respondents did not have a car for work or school trips, 1% – 8% had one car available, and 9% had two or more cars available. On average, it takes 33 min for travellers to reach their work or school. A total of 83% of respondents said they travel with other household members, while 22% said they travel with individuals from other houses. Table 2 presents a comprehensive overview of participants' travel behaviour and demographic characteristics, examining variables like household income, employment status, car ownership, and density across various levels.

Modes of transportation

This section presents an analysis of the modes of transportation used by Lusaka City residents to commute to work or school, as revealed by the survey data. Figure 2a provides information on the frequency and distribution of various travel modes among study participants.

TABLE 1: Comparison of sample population to Lusaka population demographics.

Category	Level	Sample (%)	Lusaka (GRZ 2018) (%)
Gender	Male	50.4	47.9
	Female	49.6	52.1
Age (years)	20 or less	22.0	11.0
	21–30	34.0	32.7
	31–40	26.0	22.1
	41–50	9.0	15.3
	51–60	6.0	9.4
	Above 61	3.0	9.5
Education level	No education	5.2	13.2
	Primary	8.6	41.7
	Secondary	53.4	33.7
	Higher	32.8	11.4
Household size (people)	1	4.1	10.9
	2–3	14.6	22.9
	4–5	31.3	33.5
	6–7	28.3	20.7
	8–10	21.3	10.9
	11–14	0.4	1.1

Source: Adapted from: GRZ, 2018, *Zambia Demographic and Health Survey 2018 [Dataset]*, ZMIR715V.ZIP

TABLE 2: Transportation modes by employment status and car ownership.

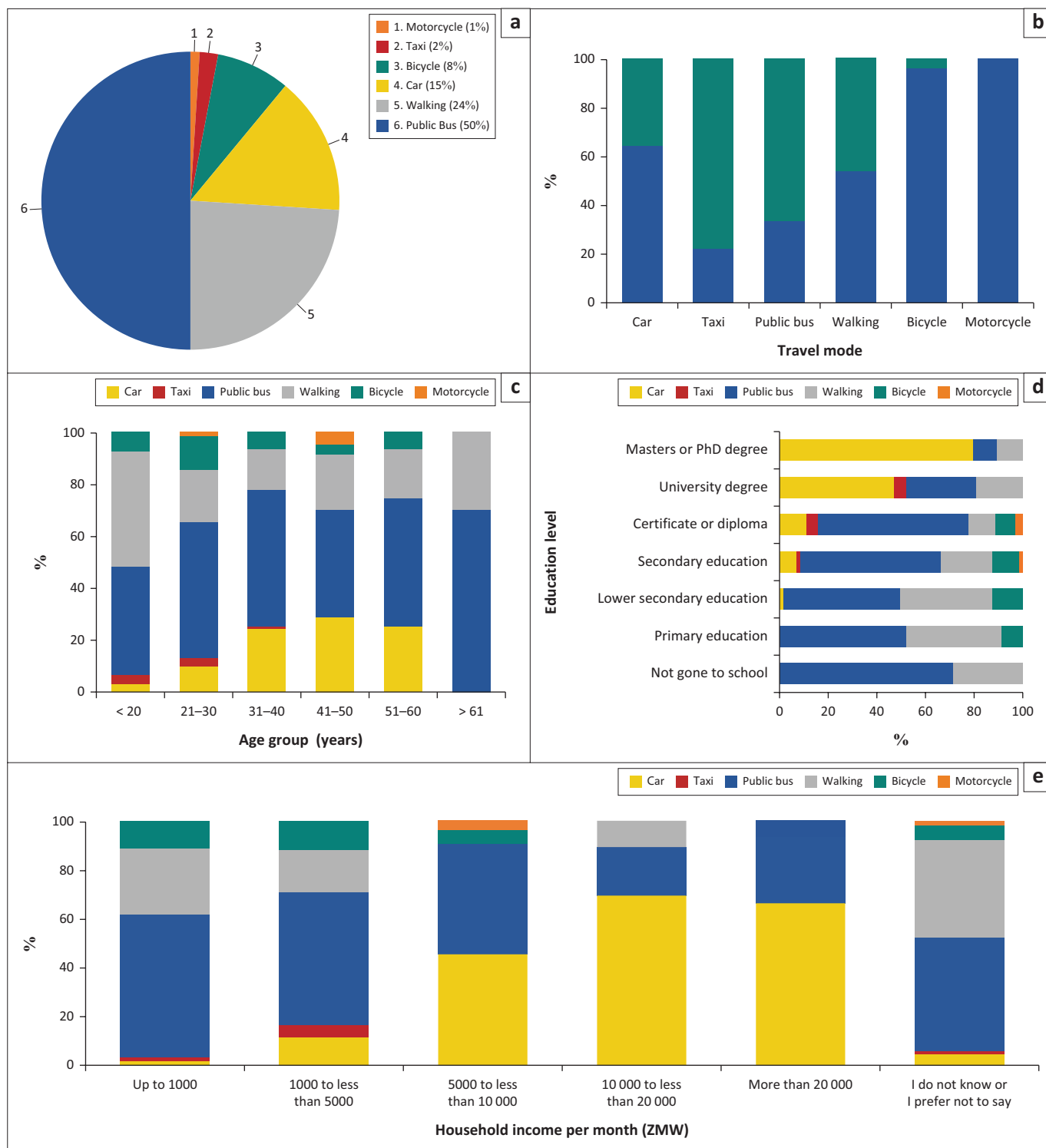
Variable	Level	Total		Car		Taxi		Public bus		Walking		Bicycle		Motorcycle	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%
Employment status	Employed full time	87	32.5	27	69.2	3	50.0	39	29.1	8	12.3	8	36.4	2	100
	Employed part time	32	11.9	2	5.1	0	0.0	22	16.4	5	7.7	3	13.6	0	0
	Student (university or college)	18	6.7	3	7.7	2	33.3	9	6.7	4	6.2	0	0.0	0	0
	Pupil (primary or highschool)	43	16.0	1	2.6	0	0.0	13	9.7	24	36.9	5	22.7	0	0
	Currently unemployed	47	17.5	2	5.1	1	16.7	31	23.1	11	16.9	2	9.1	0	0
	Housewife or househusband	9	3.4	0	0.0	0	0.0	7	5.2	2	3.1	0	0.0	0	0
	Retiree	6	2.2	0	0.0	0	0.0	3	2.2	3	4.6	0	0.0	0	0
Informal employment (business)	26	9.7	4	10.3	0	0.0	10	7.5	8	12.3	4	18.2	0	0	
Car ownership	Yes	75	28.0	37	94.9	0	0.0	26	19.4	10	15.4	1	4.5	1	50
	No	193	72	2	5.1	6	100	108	80.6	55	84.6	21	95.5	1	50

Walking and public bus are the most frequently used modes, accounting for 24% and 50% of the responses, respectively. Car usage stands at 15%, while bicycle, taxi, and motorcycle usage are reported at 8%, 2%, and 1%, respectively.

Public bus usage: Public buses emerged as the most popular mode of transport, with 50% of respondents using them regularly. Female respondents were more likely to use public buses, with 67% choosing this mode compared to 33% of males (see Figure 2b). Public bus usage was highest among respondents with lower secondary education (20%) and secondary education (37%) (Figure 2d). Respondents in the lower-income brackets were more likely to use public buses, with 25% of those earning up to 1000 ZMW per month and 32% of those earning between 1000 and 5000 ZMW per month choosing this mode. At the time of data collection, one Zambian Kwacha (ZMW) was equivalent to approximately 0.062 US Dollars (USD) and 0.063 Euros (EUR) (Figure 2e). Public bus usage was also more common among respondents who did not own a car, with 81% of non-car owners using public buses. The key challenges faced by public bus users included expensive fares, rude drivers, or conductors, overcrowding, and traffic congestion.

Walking: Walking as a mode of transport accounted for 24% of the total transport modes. Males were more likely to walk, with 55% choosing this mode compared with 45% of females. Walking was most common among respondents aged less than 20 years, with 40% of this age group choosing this mode (Figure 2c). Respondents in households with more than 10 members were also more likely to walk, with 22% of such respondents choosing this mode. Walking was more prevalent among respondents living in high-density areas, with 48% of these respondents choosing this mode. Pedestrian safety emerged as a concern because of careless or indifferent motorists. In addition, walking is the preferred mode for shorter distances and brief travel times, with around 40% of respondents who walk to their destinations reporting that they do so for journeys lasting between 2 and 10 min.

Cycling: Eight per cent of respondents reported using bicycles to commute. Males exclusively used bicycles, with 100% of bicycle users being male. Bicycle usage was most



ZMW, Zambian Kwacha.

FIGURE 2: Travel mode by: (a) percentage, (b) gender, (c) age group, (d) education status, and (e) household income.

common among respondents aged 21 to 30 years, with 55% of bicycle users belonging to this age group (Figure 2c). Bicycle usage was highest among respondents with lower secondary education (32%) and secondary education (28%) (Figure 2d). Bicycle usage was more common among respondents who did not own a car, with 95% of non-car owners using bicycles. The most significant barriers for cyclists were inadequate cycle lanes and pedestrian ways, poor road condition, and poor street lighting.

Personal motor vehicle usage: Car usage accounted for 15% of the total transport modes in the survey. Males were more likely to use cars, with 74% of male respondents opting for this mode, compared with only 26% of females. Car usage increased with higher education levels, with 51% of respondents with university degrees and 21% of those with master’s or PhD degrees choosing this mode. Additionally, car usage was more prevalent among higher-income respondents, with 41% of those earning between 5000 and

10000 ZMW per month using cars. Car ownership was also strongly associated with car usage, as 95% of car owners used their car for transportation. Traffic congestion was cited as the primary challenge faced by motor vehicle users.

Taxi usage: Taxis represented 2% of the total transport modes in the survey. The usage of taxis was more common among females, with 67% choosing this mode compared to 33% of males. Taxis were mainly used by respondents aged 21 to 30 years, with 50% of taxi users belonging to this age group. High taxi fares, fear of crime, poor road conditions, and traffic congestion were identified as the main challenges faced by taxi users.

Motorcycle usage: Motorcycle usage represented 1% of the total transport modes. As with bicycles, motorcycle usage was exclusive to male respondents. Respondents aged 21 to 30 years were most likely to use motorcycles, with 50% of motorcycle users belonging to this age group (Figure 2c). Poor road conditions was cited as the main challenge faced by motorbike users.

Comparison of results across the enumeration areas

The analysis of travel mode choices across different residential densities in Lusaka district reveals distinct patterns in transportation preferences. In high-density areas such as Chawama and Justine Kabwe wards, residents exhibit a strong preference for public transportation, particularly public buses, and walking. In contrast, medium-density areas such as Chilenge and Roma wards, demonstrate a more diverse range of transportation options, including private vehicles, public transit, taxis, and walking. Meanwhile, low-density areas such as Lubwa and Mwembeshi, show a higher reliance on private vehicles, primarily cars and motorcycles, with walking remaining important for shorter trips (see Table 3).

Factors considered when selecting a travel mode

The survey conducted in Lusaka city aimed to identify the factors that influence residents' choice of travel mode. The factors considered were environment, convenience, flexibility, dependability or reliability, comfort, fuel cost, safety, travel time, and bus or taxi fare (Figure 3). According to the survey results, the most important factors for Lusaka residents when choosing a travel mode were bus or taxi fare, travel, and safety. These factors highlight the importance of cost-effectiveness, efficiency, and security for Lusaka residents when selecting a mode of transportation. On the other hand, fuel cost and comfort were also deemed important by a significant proportion of respondents. Dependability or reliability and convenience or flexibility were also considered crucial factors, indicating that residents value consistent and adaptable travel options (see Figure 3). Lastly, the environment, including pollution and energy consumption, was a factor that a smaller portion of respondents considered very important. However, this may still be an influential factor for some individuals when selecting their mode of transportation.

Analysing the responses across different travel modes (car, taxi, public bus, walking, bicycle, and motorcycle) reveals distinctive preferences. Fuel cost is a significant consideration for car and motorcycle users, while bus and/or taxi fare influences those opting for public buses and taxis. Safety concerns, including the risk of traffic accidents or crime, are prevalent across car, taxi, and motorcycle users. Convenience and flexibility are prioritised by motorcycle and walking commuters, while travel time is a key consideration for public bus, walking, and bicycle users. Dependability and reliability are factors for car and taxi users, while environmental impact, such as pollution and energy consumption, is a concern for car and motorcycle users (see Table 4). This nuanced understanding of factors deemed important by users provides valuable insights for urban transportation planning in Lusaka city, catering to diverse user preferences.

Factors associated with travel mode choice

Participants were assessed to understand their choice of travel mode and the factors that influenced their decision. The study defined 'walking distance' as the distance that individuals are willing to travel on foot for their daily commuting trips. Similarly, 'cycling distance' is defined as the distance individuals are willing to cycle as part of their daily commuting trips. It's important to notice that the definitions of walking and cycling distance provided in the questionnaire did not specify a specific length of distance or time. Respondents were asked to provide their own perception of the distance they were comfortable walking or cycling as part of their commuting routine.

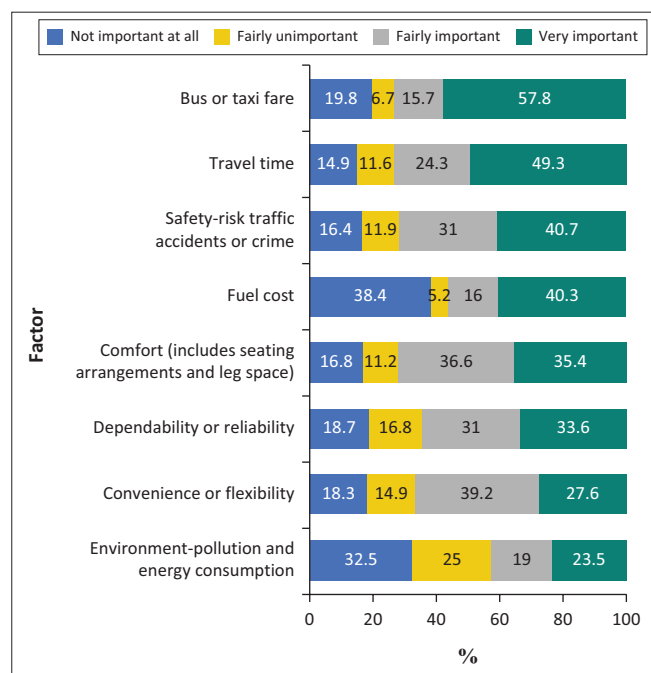
The results indicate that gender, age, education level, household income, employment status, car ownership, trip purpose, presence of children in the household, destination within walking and cycling distance, and household composition are all significantly associated with the choice of travel mode ($p < 0.05$). Males were more likely to use bicycles and motorcycles, whereas females predominantly used public buses. Age also played a role, with younger participants (< 20 years) relying more on walking and bicycles, and those aged 31 to 40 years showing a higher preference for cars. Higher education levels were associated with an increased likelihood of using cars. Car ownership was strongly correlated with travel mode choice, with 95% of car owners choosing cars as their primary mode of transportation (see Table 5).

Household income influenced travel mode choice, with higher-income participants more likely to use cars and those with lower incomes preferring public buses and walking. Employment status revealed that full-time employees were more inclined to use cars, while students and pupils showed a preference for walking and public buses. Work or business trips were associated with an increased use of cars, while school trips were linked to walking and public buses. The presence of children in the household was associated with a higher likelihood of using public buses, and destinations

TABLE 3: Travel mode choices by ward and residential density in Lusaka district.

Travel mode	High density				Medium density				Low density				Total	
	Chawama†		Justine Kabwe†		Roma†		Chilenge†		Lubwa†		Mwembeshi†		n	%
	n	%	n	%	n	%	n	%	n	%	n	%		
Bicycle	5	22.7	5	22.7	2	9.1	2	9.1	2	9.1	6	27.3	22	100
Car	6	15.4	3	7.7	7	17.9	11	28.2	5	12.8	7	17.0	39	100
Motorcycle	1	50.0	0	0.0	0	0.0	0	0.0	0	0.0	1	50.0	2	100
Public bus	17	12.7	42	31.3	13	9.7	33	24.6	3	2.2	26	19.4	134	100
Taxi	0	0.0	2	33.3	1	16.7	1	16.7	1	16.7	1	16.7	6	100
Walking	11	16.9	21	32.3	7	10.8	6	9.2	6	9.2	14	21.5	65	100
Total	40	14.9	73	27.2	30	11.2	53	19.8	17	6.3	55	20.5	100	100

†, Name of ward.

**FIGURE 3:** Factors considered when selecting a travel mode.

within walking and cycling distance showed a preference for walking and bicycles. Household composition also influenced travel mode choice, with single-person households and couples without children more likely to walk or use bicycles, and households with children showing a preference for public buses and cars.

Socio-demographic factors and travel mode choice

The study examined the association between various socio-demographic factors and the mode of transportation preferred by individuals. Pearson's Chi-squared test was used to assess the relationship between each factor and the preferred mode of transportation. The results showed significant associations for gender, age, education level, income, household designation, employment status, vehicle ownership, trip purpose, presence of children, walking or cycling distance, and household size. The findings from the contingency table analysis are summarised in Table 5.

A post hoc analysis, using adjusted standardised residuals, was conducted to further explore the specific categories that contribute to the observed significance. The adjusted

TABLE 4: Factors considered important in travel mode choices by users in Lusaka city.

Factor considered	Travel mode					
	Car	Taxi	Public bus	Walking	Bicycle	Motorcycle
Fuel cost	x	-	-	-	-	x
Bus or taxi fare	-	-	x	x	-	x
Comfort (this includes seating arrangements and leg space)	x	-	-	-	-	-
Convenience or flexibility (ability to travel wherever and whenever you want)	x	-	-	-	-	x
Safety-risk traffic accidents or crime	x	x	x	-	-	x
Travel time	x	-	x	-	x	-
Dependability or reliability	x	x	-	-	-	-
Environment-pollution and energy consumption	x	x	-	-	-	-

standardised residuals used in the post hoc analysis are presented in Table 5. The residual analysis confirmed that there were statistically significant differences in the associations between mode choice and demographic factors. Males were more likely to choose cars, bicycles, and motorcycles, while females favoured taxis, public buses, and walking. Younger individuals (0–20 years) preferred walking, while those aged 21–30 years chose bicycles. Participants aged 31–40 years and 41–50 years showed a higher preference for cars, and those aged 61 years and above preferred public buses. Individuals with higher education and income levels were more likely to use cars, while those with lower education and income levels were more likely to walk, use public buses, or ride bicycles.

Household designations revealed that single-person households and couples without children were more likely to walk or use bicycles, while couples with children and single parents predominantly opted for cars. Employment status also impacted transportation choices, with full-time employees preferring cars and motorcycles, and students favouring public buses and walking. Vehicle ownership had a significant effect on transportation mode choices, with those owning a vehicle predominantly using cars and those without vehicles more likely to use other modes of transportation. Trip purpose, presence of children in the household, walking or cycling distance to work, and household size all had significant associations with transportation mode choices.

TABLE 5: Contingency table analysis and summary of the key results from the post hoc analysis.

Variable	Chi-squared	<i>p</i>	Main findings from the post hoc analysis
Gender	50.456	1.118e-09**	Males more likely to use cars, bicycles, and motorcycles; Females more likely to use public buses and walking
Age	43.740	0.01159*	Younger individuals prefer walking, bicycles; Older individuals prefer cars and motorcycles
Education	113.650	1.16e-11**	Higher education levels linked to higher car usage; Lower education levels linked to higher use of public bus and walking
Income	96.991	2.005e-10**	Higher income individuals prefer cars; Lower income individuals prefer public bus and walking
Household designation	69.401	0.002686**	Single-person households and students prefer walking; Couples with children prefer cars
Employment	86.991	2.571e-06**	Employed individuals prefer cars; Students and unemployed individuals prefer public bus and walking
Vehicle ownership	105.400	< 2.2e-16**	Vehicle owners prefer cars; non-vehicle owners prefer public bus and walking
Trip purpose	46.260	1.287e-06**	Work trips mainly by car; School trips mainly by walking and public bus
Children	17.003	0.004495*	Households with children prefer cars; Households without children prefer public bus and walking
Work commute distance	35.640	1.121e-06**	Longer work commutes associated with walking; Shorter work commutes associated with cars and public buses
Household size	27.974	0.309	No significant differences found

Note: < 2.2e-16 indicates extremely small *p*-values.

*, *p* < 0.05; **, *p* < 0.01; ***, *p* < 0.001.

Individuals living in high-density areas are more likely to choose public bus and motorcycle, while those living in low-density areas are more likely to choose car and bicycle. Individuals who live within walking and cycling distance are less likely to choose public bus and more likely to choose walking, while those who do not live within walking and cycling distance are less likely to choose walking and more likely to choose public bus. Those travelling for work or business are more likely to choose car, while those travelling for school are more likely to choose walking and public bus. Individuals living with children are more likely to choose car and public bus, while those living without children are more likely to choose walking and bicycle. These main findings and interpretations of the residual analysis are summarised in Table 5.

Discussion

The research aimed to address the following central question: 'What is the current mode split for work and school trips, and what factors influence mode selection in Lusaka?' The study findings highlight the prominence of non-motorised and public transport modes, which account for a substantial proportion of the city's mobility patterns.

Mode split for work and school trips in Lusaka city

In Lusaka city, the mode split for work and school trips unveils a dynamic landscape of transportation preferences.

Notably, the most prevalent modes employed by residents are walking and public buses, constituting 24% and 50% of the reported responses, respectively. The usage of cars for work and school trips was reported to be 15%, while the usage of bicycles, taxis, and motorcycles are 8%, 2%, and 1%, respectively.

Public buses

Our findings indicate that public buses are the primary mode of transportation in Lusaka city for work or school trips, with 50% of respondents using them. Our study results show that the majority of respondents live further than walking and cycling distance from their places of employment or educational institutions, underscoring the significant impact of Lusaka's sprawling urban form on daily commutes. This urban sprawl not only stretches the city's boundaries but also increases the reliance on motorised transportation, contributing to longer travel times and less sustainable commuting practices.

The attractiveness of public buses as a mode of transportation is not only due to their physical accessibility but also their affordability relative to household incomes. A study conducted in Addis Ababa indicates that, on average, households spent approximately 14% of their income to public transport costs (Mohammed & Senadheera 2022). This proportion is considerably lower compared to personal vehicle costs, making public buses a financially viable option for many residents. Additionally, the perception of quicker travel times, despite frequent violations of traffic laws by bus drivers, further enhances the appeal of buses for daily commutes (Transaid 2021). The relatively low cost and high accessibility of public buses in the city make them an attractive option for a significant portion of the population. In addition, public bus drivers in cities across Zambia are known for frequently disregarding traffic laws, often manoeuvring onto pavements and side roads to avoid traffic congestion (Kavuyi 2017). This practice has created a perception that they can reach their destinations more quickly than those in personal vehicles. These factors contribute to the popularity of public buses as the primary mode of transportation for work or school trips in Lusaka.

Our study builds upon the findings of Chikuba (2014) by delving deeper into the nuances of public bus usage challenges in Lusaka, notably overcrowding and unreliability. These issues are not unique to Lusaka but are echoed in other developing urban areas, such as Dar es Salaam (Nkurunziza et al. 2012). The comparison underlines a common urban challenge across different contexts, suggesting a shared need for comprehensive public transportation improvements. To address these, investing in public bus infrastructure should be prioritised. This includes increasing the bus fleet, implementing reliable scheduling, and conducting training for better customer service. Further, policy interventions such as fare subsidies for low-income passengers should be considered to maintain affordability.

Walking and cycling

Walking was the second most popular mode of transportation for home to work or school trips, accounting for 20% of respondents' preferences. The similarity between our findings and those reported in Enugu, Nigeria, by Nwachukwu et al. (2023) underscores a common trend in developing African cities where walking remains a critical mode of transport due to factors such as urban form, economic considerations, and the availability of infrastructure. Urban planning and policies should prioritise walkability and mixed-use development to reduce the need for private vehicles. Cycling was preferred by 8% of respondents, with men being more likely to cycle than women, a finding consistent with research conducted in other African cities (Mendiate et al. 2022). Inadequate infrastructure and safety concerns were identified as the main barriers to cycling.

To encourage more walking and cycling, policymakers should invest in pedestrian and cyclist safety by improving road infrastructure such as dedicated cycle lanes, well-maintained pedestrian paths, and sufficient street lighting.

Private cars, taxis and motorcycles

Private car usage in Lusaka city, accounting for 15% of respondents' preferences, is mainly driven by convenience and flexibility, which mirrors findings in other African cities (Diaz Olvera, Plat & Pochet 2020). To discourage private car use and single occupancy vehicles, particularly in the context of Lusaka and other lower-middle-income cities, a range of policy recommendations such as congestion pricing and car-sharing schemes can be considered (Tao, Nie & Zhang 2021).

Safety concerns are not only prevalent among motorcycle users, the least popular mode of transportation with only 1% of respondents opting for this choice, but also extend significantly to cyclists. The current state of cycling infrastructure in Lusaka presents several challenges that contribute to the safety concerns highlighted by respondents. As it stands, the city's infrastructure for cyclists is markedly underdeveloped, with limited dedicated bicycle lanes and often inadequate road sharing practices, leading to increased risks for cyclists (GRZ 2019b). To improve safety, traffic regulation enforcement should be prioritised (WHO 2018). By addressing these challenges, policymakers can promote a diverse range of transportation options that reduce private car use and contribute to more sustainable urban mobility.

Travel mode choice and residential density

The findings suggest that transportation preferences vary based on residential density in Lusaka district. In high-density areas, public transportation and walking are predominant, while medium-density areas exhibit a mix of transportation modes, and low-density areas rely heavily on private vehicles. The correlation between residential density and transportation choices is significantly influenced by a range of socioeconomic factors. These include, but are not limited to, income levels, household size, and the availability

of household resources such as car ownership. For instance, higher-income households, which are more prevalent in low-density areas, tend to have greater access to private vehicles and consequently show a higher preference for driving. In contrast, lower-income households, often situated in high-density areas, may rely more on public transportation or non-motorised modes like walking and cycling due to the lower costs associated with these options. Additionally, the size and composition of households can influence transportation choices; larger families might prefer the convenience of private vehicles, while individuals or smaller households may opt for public transport or walking, especially if these modes are readily accessible and economically advantageous (Brownstone & Fang 2014; Lotfi, Despres & Lord 2019).

To address these differences, policymakers should focus on enhancing public transit infrastructure in high-density areas, promoting modal integration in medium-density areas, and improving transportation equity and accessibility in low-density areas. By tailoring interventions to the specific needs of each area, policymakers can improve transportation efficiency and contribute to urban liveability in Lusaka city.

Factors associated with travel mode choice

Our study explored the factors influencing travel mode choice in Lusaka city and revealed that several socio-demographic factors were significantly associated with the preferred mode of transportation. These factors included gender, age, education level, income, household designation, employment status, vehicle ownership, trip purpose, presence of children, walking or cycling distance, and household size.

Income, distance to work and/or school, and household car ownership also emerged as significant determinants of travel mode choice. Notably, lower-income households and longer travel distances were associated with a higher likelihood of using public transport or non-motorised modes. Given Lusaka's income distribution and sprawling urban form, these findings underscore the vital role of affordable, efficient, and sustainable public transportation and NMT infrastructure. The gender of the respondents also exhibited an intriguing correlation with travel mode choice. The post hoc analysis showed that males were more likely to use cars, bicycles, and motorcycles, while females favoured taxis, public buses, and walking. The gender differences in travel mode preferences observed in this study have also been reported in a study on travel behaviour by gender (Wei-Shiuen & Ashley 2018). Our study also found that higher education and income levels were associated with increased car usage, while those with lower education and income levels were more likely to walk, use public buses, or ride bicycles. Higher education and income levels are associated with increased car usage, likely because of greater affordability and accessibility, while lower education and income levels are correlated with walking, public bus usage, or bicycle riding, possibly reflecting economic constraints and alternative transportation preferences. Household composition, employment status, vehicle ownership, trip

purpose, the presence of children, walking or cycling distance, and household size all influenced transportation mode choices.

Initiatives targeting these factors, such as women-specific cycling programmes, age-friendly infrastructure, congestion pricing, car-sharing schemes, safe routes to school programmes, and compact urban design, can contribute to the promotion of sustainable transportation behaviours.

Comparative analysis of transportation preferences in African cities

The transportation preferences observed in Lusaka, Zambia, reveal unique insights that can be compared with findings from travel behaviour studies conducted in other African cities. Comparing these findings with other African cities highlights both similarities and differences in transportation patterns.

In Lagos, Nigeria (Amiegbebor & Poopola 2021), as in Lusaka, public buses are a primary mode of transportation, although Lagos faces challenges with traffic congestion and reliance on informal transit options such as 'danfoes' and 'molues'. Similarly, Accra, Ghana, and Dar-es-Salaam, Tanzania experience congestion issues and rely on shared minivans (trotros and dala-dalas) for urban transportation, although efforts to improve public transit infrastructure are underway in both cities (Infrastructure Consortium for Africa 2023; Poku-Boansi, Amoako & Obeng Atuah 2019). Comparing travel behaviour between Lusaka and Nairobi and Kisumu, Kenya (Tatah et al. 2023), reveals distinct patterns. Lusaka's preferences are influenced by residential density, with high-density areas favouring public transport, medium-density areas showing diversity, and low-density areas relying more on private vehicles. In contrast, Nairobi and Kisumu show differences in trip-making and mode of transportation. While walking is common in both Lusaka and the Kenyan cities, other modes vary. Kisumu sees prominence in motorcycles and matatus, while Nairobi has higher usage of matatus, cars, and buses. Gender, income, and occupation also influence travel behaviour differently across the locations.

Our findings, when compared with a recent study conducted in Harare, Zimbabwe, by Kanyepe (2023), highlight consistent patterns in high-density areas. These trends favour public transportation and walking as preferred modes of travel because of residential density and its impact on traffic congestion. However, low-density areas in Lusaka exhibit a higher reliance on private vehicles than their counterparts in Harare. Both studies indicate a positive influence of residential density and travel behaviour on traffic congestion, with the Harare study specifically identifying travel behaviour as a partial mediator.

Across the continent, studies emphasise the importance of active mobility (walking, cycling) and efficient public

transportation for sustainable urban mobility. While transportation preferences and challenges may vary across African cities, there is a shared recognition of the need for efficient, safe, and sustainable mobility solutions tailored to each city's context and unique socio-demographic factors.

Limitations

Our study presents certain limitations that deserve consideration. First and foremost is the potential representativeness of our sample. It's worth noting that while we have aimed to draw insights into the Lusaka population's travel mode choices, certain differences between our sample and the broader Lusaka population may exist because of specific sampling methods and other unaccounted factors. Furthermore, it's important to acknowledge that certain demographic groups, including elderly individuals, are underrepresented in our study. Therefore, caution is advised when generalising our findings to the broader context. In addition, we must recognise the inherent limitations associated with self-reported data. Such data can be influenced by factors such as recall bias and social desirability bias, which may impact the accuracy of the information collected.

To enhance the robustness of future research, we recommend the exploration of more comprehensive methodologies, such as the use of travel diaries or Global Positioning System (GPS) tracking devices to obtain more objective data. Longitudinal research designs may also offer insights into changes in travel behaviour over time. Additionally, conducting studies that investigate the impact of specific policy interventions on travel behaviour can provide valuable insights into promoting sustainable transportation, particularly in LMICs.

Conclusion

Our study contributes to the understanding of travel behaviours and mode preferences in urban areas, particularly in the Global South. Public buses are the primary mode because of their low cost and accessibility, despite challenges like overcrowding. Walking is also popular, especially for short distances, highlighting the importance of pedestrian-friendly infrastructure. Cycling, although less common, is favoured for longer trips, indicating a potential for promoting cycling as a sustainable mode. Private car usage, while significant, is driven by convenience and flexibility and could be discouraged through policies such as congestion pricing. Differences in transportation preferences are observed based on residential density, with high-density areas relying more on public transport and walking, and low-density areas favouring private vehicles. Socio-demographic factors such as income and education level also influence mode choice, suggesting the need for tailored interventions to promote sustainable transportation. Comparisons with other African cities underscore the importance of active mobility and efficient public transportation for urban mobility across the continent, despite variations in transportation patterns and challenges.

Importantly, our research addresses notable gaps in the existing literature regarding travel mode share and mode selection within cities in the Global South. By providing insights into the transportation patterns and preferences of Lusaka residents, we contribute valuable knowledge for policymaking and urban planning initiatives aimed at fostering sustainable transportation systems. Our study lays the groundwork for future research to delve deeper into these dynamics and assess the effectiveness of policy interventions in promoting sustainable urban mobility in developing cities.

In conclusion, our study offers significant scientific contributions by enriching the understanding of travel behaviours and mode preferences in Lusaka, Zambia, and similar urban contexts. By identifying key factors influencing travel mode selection and highlighting the importance of sustainable transportation policies, our research serves as a catalyst for advancing equitable and environmentally friendly transportation systems in the Global South.

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Competing interests

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Authors' contributions

M.M. contributed to conceptualisation, draft preparation, methodology, analysis and visualisation. R.L. and N.P. were responsible for conceptualisation, supervision, review and editing. All authors have read and agreed to the published version of the manuscript.

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Data availability

The data that support the findings of this study are available on request from the corresponding author, M.M.

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