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Investigating the Mobility Challenges Faced by Women in an Urban Area of a Low and Middle-Income Country: A Case Study of Yaoundé, Cameroon

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Abstract: Mobility is a fundamental component of urban life, yet in many cities, transport systems are designed without considering the distinct mobility patterns and safety needs of women. Despite the severity of these issues, the gendered dimensions of transport remain largely invisible in research and policy. To address these gaps, this study assesses the inclusivity of transport options in Yaoundé, Cameroon. Quantitative data was collected from 345 participants, and seventeen intersections were assessed via spatial analysis. The data was then analyzed using logistic regression, association analysis, and cluster analysis to model women's mobility patterns, trip complexities, and safety perceptions. The findings reveal that women face disproportionate exposure to harassment, with a staggering 97% of respondents reporting victimization. This problem is compounded by inadequate infrastructure; 53% of the audited intersections lacked functional street lighting, and 70% had no marked crosswalks. Age and income levels are significantly associated with mobility choices. For each unit increase in income, the odds of a woman using a private car instead of a motorcycle increased by 66% (Odds Ratio = 1.662, $p < 0.001$), while older women were more than twice as likely to opt for taxis (OR = 2.052, $p = 0.006$). Cluster analysis identified six distinct user profiles, with the "Vulnerable Female Pedestrian" and "Young Women on Motorcycles" clusters reporting the highest rates of harassment (96–98%). These findings demonstrate that women's mobility choices are dictated by a trade-off between affordability and pervasive safety threats. The research concludes that achieving gender-equitable transport in Yaoundé requires targeted interventions, including safer infrastructure and gender-sensitive policy enforcement.

Keywords: women's mobility; road transport; gender-sensitive planning; urban safety; transport equity; harassment

1. Introduction

Mobility is a fundamental component of urban life, enabling access to economic opportunities, education, healthcare, and social participation. However, transport systems in many cities worldwide are designed without considering the distinct mobility patterns and safety needs of women, perpetuating gender inequalities and

constraining women's freedom of movement [1,2]. Women's mobility in urban contexts is complex and characteristically distinct from that of men. Women disproportionately engage in trip-chaining, a pattern of sequential, multi-stop journeys that combine productive activities such as employment with reproductive responsibilities including escorting children to school, visiting health facilities, purchasing household goods, and providing caregiving. These non-linear, multi-destination trips are poorly served by hub-and-spoke or fixed-route transit systems designed for peak-hour, point-to-point commuting. Women also face pervasive safety threats in transport environments, encompassing sexual harassment, physical assault, verbal abuse, and theft, all of which restrict when, where, and how they travel. Fear of harassment during late-night hours effectively imposes a mobility curfew on women, constraining their access to evening employment, education, and social participation. Affordability barriers further intersect with safety constraints: where safe transport options such as private vehicles are financially inaccessible, women are compelled to use cheaper but more dangerous modes, including informal commercial motorcycles, or to walk along poorly lit roads. Taken together, these patterns constitute a gendered mobility disadvantage that transport planning has historically rendered invisible. This phenomenon is particularly acute in cities of the Global South, where rapid urbanization, limited public investment, and gender-blind planning have resulted in transport systems characterized by poorly maintained infrastructure, weak regulation, and a predominance of informal services [3–5].

Yaoundé, the capital city of Cameroon with a population exceeding 3 million, exemplifies these challenges. The city's transport system has been described as problematic, with approximately 8 million daily trips occurring through a fragmented network of informal services including shared taxis, commercial motorcycle taxis (locally known as "benskins" or "moto-taxis"), minibuses, and private vehicles. Women, who constitute substantial users of road transport in Yaoundé, face disproportionate risks including harassment, limited access to safe and reliable transport options, and longer travel times due to caregiving responsibilities that necessitate complex trip-chaining patterns [6].

The gendered dimensions of urban mobility have been increasingly recognized in international development discourse, with organizations such as the World Bank, Asian Development Bank, and UN Women highlighting the need for gender-responsive transport planning [7,8]. Yet despite this growing acknowledgment, existing transport infrastructure continues to be designed around what can be termed male-centric, linear commuting, a planning paradigm that privileges a single daily round-trip from home to a formal workplace and back, during standard peak hours [9–11]. This model reflects the travel behavior historically associated with male breadwinners in formalized employment and underlies the design of major arterial roads, bus routes, and metro systems in most cities, including those of Sub-Saharan Africa. It is structurally ill-suited to the complexity of women's daily mobility, which involves multiple trip legs at varied times of day, traversal of secondary and tertiary roads connecting residential neighborhoods to markets and schools, and frequent travel outside conventional peak windows. The consequences are concrete: infrastructure designed around the linear commuter systematically neglects pedestrian facilities on secondary streets, off-peak transit service, safe waiting areas near markets and health centers, and lighting along residential pathways, all of which are disproportionately critical for women's safety and access [12,13].

The literature on feminist geography has long critiqued urban planning paradigms that perpetuate gender inequalities by prioritizing male-centric mobility patterns over women's fragmented, multi-purpose journeys [9,10,14]. Women's travel behavior is fundamentally shaped by their disproportionate responsibility for unpaid care work, including childcare, eldercare, and household maintenance, generating spatial-temporal constraints that fixed-route, peak-hour systems are structurally unable to accommodate [8]. In Yaoundé specifically, approximately 45% of the population relies on public transport and 25% on active mobility (walking and cycling), with women facing pronounced barriers including fear of traffic injuries, inadequate infrastructure, and pervasive safety concerns [6].

Women's lower access to private vehicles further compounds their mobility challenges. Across Sub-Saharan Africa, women own vehicles at significantly lower rates than men due to lower incomes, limited access to credit, and also cultural norms that prioritize male vehicle ownership [10,15]. This forces women to rely heavily on informal public transport services that are often unsafe, unreliable, and ill-suited to their complex travel needs. In contexts where formal public transport is underdeveloped or non-existent, women must choose between walking long distances exposing themselves to physical danger and time loss or using informal modes such as commercial motorcycles that carry their own safety risks [16]. Safety concerns constitute a critical barrier to women's mobility across diverse geographic contexts. Safety in transport encompasses physical, psychological, and social dimensions, including freedom from harassment, violence, theft, and road crashes [17]. Research from cities across Africa, Asia, and Latin America consistently documents that women experience high rates of gender-based violence in transport settings, ranging from unwanted staring and verbal harassment to physical assault and sexual violence [18,19]. These experiences create a "fear factor" that constrains women's mobility, particularly during evening hours, forcing them

to modify travel routes, limit trip-making, or incur additional costs for perceived safer modes [20]. Feminist geography scholars have theorized how public spaces, including transport infrastructure and vehicles, become sites of surveillance and vulnerability for women through the operation of the "male gaze" [9,14]. The design of urban transport systems from the location and lighting of bus stops to the absence of women-only compartments often fails to account for women's differential experiences of public space as potentially threatening environments.

Women's transport experiences cannot be understood through a single-axis framework that treats "women" as a homogeneous category. Rather, as Ref. [21] articulated in their foundational work on intersectionality, women's experiences of disadvantage are shaped by the intersection of multiple social identities including gender, class, age, ethnicity, and disability status. Recent transport research has begun to apply intersectional frameworks to understand how these overlapping identities create distinct patterns of mobility constraint and vulnerability [1,4,22,23]. In the context of Yaoundé, economic vulnerability intersects with gender to profoundly shape transport access. Lower-income women, who constitute the majority of female transport users, face a particularly acute trade-off between affordability and safety. The cheapest modes, walking and commercial motorcycles, expose women to the highest safety risks, while more expensive options like private taxis or ride-hailing services remain financially out of reach for daily use [6]. Younger women face distinct challenges related to sexual harassment, while older women may face physical accessibility barriers due to poorly maintained infrastructure. Women with disabilities confront compounded barriers in transport systems that lack universal design features such as curb cuts, ramps, and accessible vehicles.

This study's analysis is grounded in established theories of travel behavior, specifically the Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB) [24,25]. The TRA posits that behavioral intention, the immediate antecedent of actual behavior is determined by two factors: attitudes toward the behavior and subjective norms. In the transport context, a woman's attitude toward using a particular mode (e.g., commercial motorcycle) is shaped by her beliefs about its attributes, such as cost, speed, and safety. Subjective norms reflect perceived social pressure, such as family or community expectations regarding appropriate transport for women. The TPB extends this framework by introducing the concept of Perceived Behavioral Control (PBC) an individual's perception of their ability to perform the behavior, given available resources and anticipated obstacles [25,26]. For women in Yaoundé, PBC is constrained by multiple factors: inadequate street lighting reduces their ability to safely walk at night; complex or expensive transport systems reduce their ability to make necessary trips; and pervasive harassment reduces their sense of control over their travel experience. These constraints interact with attitudes and norms to shape women's actual mobility choices, often resulting in travel suppression (choosing not to make trips) or temporal/spatial avoidance strategies (traveling only during daylight hours or avoiding certain routes) [20].

The TRA and TRB frameworks function as conceptual lenses of this study that guided the design of the survey instrument, the selection of analytical variables, and the interpretation of empirical patterns, rather than as formally tested models with explicitly measured latent constructs. Survey items related to attitudes toward safety, perceived social norms around transport use, and perceived control over transport choices are conceptually informed by TRA and TPB but are analyzed as observed variables in chi-square and regression frameworks rather than as operationalized constructs in a structural equation model.

While TRA and TPB are closely related, with TPB constituting a direct extension of TRA, their joint application in this study is substantively motivated. TRA posits that transport mode choices are driven by two core evaluative components: the individual's belief that a given behavior will lead to certain outcomes, and the normative pressure exerted by significant social referents regarding what constitutes acceptable transport behavior for women. TPB extends this framework by introducing perceived behavioral control, which captures the individual's assessment of whether the behavior is realistically within their capacity to execute given constraints such as cost, physical access, and mode availability. In a gendered transport context, the two frameworks operate synergistically. TRA explains why women may hold negative attitudes toward unsafe modes yet still regard them as acceptable under social pressure, while TPB explains why structural and economic constraints may override both attitude and social norms in shaping actual behavior. Together, they offer a theoretically grounded basis for interpreting why women remain confined to low-quality transport modes even when deeply dissatisfied with their safety implications. In this study, the role of intersectionality is conceptual and interpretive, informing the decision to conduct income- and age-disaggregated analysis and to pursue cluster-based profiling of user groups.

Despite growing international recognition of gender gaps in transport, empirical research on women's mobility in Sub-Saharan African cities remains limited, and policy responses have been minimal. Yaoundé presents a particularly critical case for investigation due to the severity of its transport challenges, the high reliance on informal modes, and the documented prevalence of harassment and safety concerns among female users. Existing studies have documented broad patterns of mobility disadvantage [6,27], but no comprehensive empirical

analysis has systematically examined the intersection of infrastructure quality, transport mode choice, trip complexity, and safety experiences specifically for women in Yaoundé. This research addresses this gap by providing detailed, context-specific evidence on women's mobility challenges in Yaoundé through rigorous quantitative surveys, infrastructure audits, and advanced statistical modeling. Against this backdrop, this study makes several specific contributions to the literature. It is among few quantitative studies to systematically profile distinct female transport user typologies in a Francophone Central African city through cluster analysis, moving beyond aggregate gender-disaggregated statistics to reveal within-group heterogeneity in mobility vulnerability. The study integrates supply-side infrastructure audit data with demand-side survey data in a unified analytical framework, enabling direct empirical linkages between physical infrastructure deficiencies and women's safety perceptions and mode choices, an approach that remains uncommon in Sub-Saharan African urban transport research. It generates empirically grounded, cluster-specific policy recommendations rather than generic gender-mainstreaming prescriptions, thereby offering urban planners and transport authorities more targeted and actionable guidance. By situating the analysis in the context of an informality-dominated transport system, the study also diversifies the empirical base in gendered transport research, which remains disproportionately concentrated in cities with formal or semi-formal public transit.

The primary aim of this study is to investigate the mobility and safety challenges faced by women in Yaoundé's road transport system. The specific objectives are:

(1) Assess the gender inclusivity and accessibility of transport options at seventeen high-risk locations in Yaoundé through infrastructure audits and user surveys;
(2) Evaluate the security conditions and experiences of harassment encountered by women during their transport journeys, disaggregated by mode, time, and location;
(3) Analyze the influence of socio-demographic factors (age, income, education, employment) and infrastructure quality on women's modal choices;
(4) Identify distinct profiles of female transport users through cluster analysis, revealing differentiated patterns of vulnerability and mobility constraint.

By s documenting the barriers women face and quantifying their impacts on mobility choices and safety perceptions, this research provides a critical foundation for gender-responsive transport policy and planning in Yaoundé and similar Sub-Saharan African cities.

2. Methods and Materials

2.1. Research Design

This study employs a quantitative-primary, multi-source research design, drawing on two structured data collection instruments: an infrastructure audit at 17 identified high-risk locations across Yaoundé and a structured questionnaire survey administered to 345 women aged 18 and above. The infrastructure audit was conducted using a standardized observation checklist to record the presence or absence of key safety-related physical attributes at each site, including pedestrian lighting, marked crosswalks, sidewalk provision, vendor encroachment, and visibility conditions. Findings from the audit are reported as descriptive quantitative measures and serve to characterize the supply-side context within which women make transport decisions. The survey instrument captured socio-demographic characteristics, transport mode usage, safety perceptions, and harassment experiences. The two data sources are analyzed separately and jointly to establish empirical linkages between infrastructure conditions and user-reported outcomes.

2.2. Study Area

Yaoundé, the capital of Cameroon, serves as the study area. With a population exceeding 3 million, the city faces severe transport challenges characterized by inadequate infrastructure, traffic congestion, high crash rates, and dominance of informal transport services. According to the Plan de Mobilité Urbaine Soutenable [28], approximately 8 million trips occur daily in Yaoundé, with one-third being short-distance journeys predominantly made by walking or commercial motorcycle modes disproportionately used by women. The transport system comprises a mix of shared taxis, commercial motorcycles (locally known as "benskins" or "moto-taxis"), minibuses, private vehicles, and walking, with minimal formal public transport infrastructure.

Yaoundé was selected as the study area on the basis of several converging considerations. The city represents a rapidly urbanizing, mid-sized Sub-Saharan African capital, a category that is systematically underrepresented in gendered transport literature, which tends to concentrate on megacities such as Lagos, Nairobi, and Johannesburg, or on cities in the Global North. Its intermediate scale and administrative importance make it analytically

significant and broadly representative of urban transport challenges facing Francophone Central Africa. The transport system is characterized by an exceptionally high degree of informality: formal public transit is virtually absent, and the vast majority of passenger trips are served by informal shared taxis and moto-taxis, creating an environment in which service quality, safety standards, and accountability mechanisms are largely absent. This context of informality is theoretically important because informal transport has been consistently identified in the literature as a primary site of gender-based harassment and exclusion. Data from Cameroon's Institute National de la Statistique and local knowledge indicate that Yaoundé exhibits a combination of high female labor force participation, steep topography that limits walkability, low vehicle ownership rates, and concentrated poverty, conditions that together produce acute and measurable gendered transport vulnerability.

2.3. Sampling and Data Collection

2.3.1. Infrastructure Site Selection

Seventeen road segments (14 intersections and 3 linear sections) were purposively selected for detailed infrastructure assessment based on four criteria: (1) high road crash frequency (>10 crashes annually); (2) high Annual Average Daily Traffic (AADT) indicating heavy pedestrian and vehicular flow; (3) proximity to essential infrastructure (schools, markets, healthcare facilities, commercial centers); and (4) presence of informal economic activities that attract female users. These criteria ensured the selected sites represented locations where women's safety concerns are most acute. Field observations and infrastructure audits were conducted on 24 January 2025, using structured checklists based on pedestrian safety assessment frameworks [29,30] and digital tools (iPhone 12 Pro Max for GPS coordinates and photographic documentation).

2.3.2. Survey Sample Size Determination

The target population comprised women aged 18 years and older residing in Yaoundé who use road transport at least once per week. Given the large and undefined total population, the sample size was calculated using the Cochran formula for infinite populations [31]:

$$n = \frac{Z^2 P(1-P)}{E^2} \tag{1}$$

where:

- n is the required sample size
- P is the percentage of occurrence of a state or condition
- E is the percentage maximum error required
- Z is the value corresponding to level of confidence required

For this survey, the Margin of Error (E) was set at 5.43% ($E = 0.0543$), following conventional standards for social science research [32]. This represents the acceptable range of deviation from true population values. For the proportion estimate (P), a conservative value of 50% ($P = 0.5$) was adopted to maximize variance and ensure the largest possible sample size when population characteristics are unknown. Considering a confidence level (Z): 95% confidence ($Z = 1.96$), the minimum required sample size will be 326. The study successfully collected data from 345 participants meeting the required sample size. Simple random sampling was employed to ensure each potential participant had an equal probability of selection, enhancing the representativeness of the sample.

2.3.3. Data Collection Instruments

A structured questionnaire was developed in both English and French to accommodate Cameroon's bilingual context. The questionnaire comprised four main sections covering socio-demographic characteristics (age, household income, education level, employment status, vehicle ownership, and household composition); mobility and activity patterns (primary transport mode(s) used, frequency of use, trip purposes including work, study, shopping, childcare, healthcare, and leisure, travel times, and trip complexity indicators); infrastructure and service perceptions (assessments of accessibility, affordability, reliability, comfort, and safety of different transport modes; perceptions of infrastructure quality including sidewalks, lighting, and signage); and harassment and discrimination experiences (types of harassment experienced such as verbal, physical, unwanted staring, theft, and sexual assault, frequency, locations, times of day, and perpetrator characteristics).

Data collection was conducted through structured questionnaire sessions organized in facilitated group settings. Rather than following a traditional open-ended focus group discussion protocol, these sessions were designed as structured data collection events in which groups of women convened together to complete the survey

instrument under researcher supervision. This approach was adopted to facilitate recruitment of participants across diverse socio-economic and geographic contexts, to enable researchers to provide real-time clarification on questionnaire items thereby improving response quality, and to create a structured, semi-private environment conducive to responding to sensitive questions about personal safety and harassment experiences. The sessions did not generate thematic qualitative transcripts; accordingly, all empirical analysis in this study is grounded in the quantitative survey data collected during these sessions.

Infrastructure audits utilized a comprehensive checklist inspired by pedestrian safety assessment tools [29,30]. The checklist evaluated sidewalk presence, width, and condition; street lighting presence and functionality; vertical signage (regulatory and warning signs); horizontal signage (pavement markings, crosswalks); physical separation between pedestrians and vehicles; pavement surface quality; and accessibility features (curb ramps, tactile paving).

2.4. Statistical Analysis Methods

Data analysis was conducted using SPSS version 27 and R Program version 4.4.0. Three primary analytical techniques were employed: association analysis, multinomial logistic regression, and cluster analysis.

2.4.1. Association Analysis (Chi-Square Test of Independence)

Chi-square tests [33] were used to examine associations between categorical variables such as the relationship between age group and harassment frequency, or between income level and transport mode choice. The chi-square test evaluates whether the observed distribution of frequencies across categories differs significantly from what would be expected if the variables were independent. The null hypothesis posits that the two variables are independent, while the alternative hypothesis suggests an association exists. The null hypothesis is rejected in favor of the alternative hypothesis if the computed chi square value exceeds the critical value for the chosen significance level ($\alpha = 0.05$ or 5%). Another parameter, Cramér's V indicates the strength of the association. It ranges from 0 (no association) to 1 (perfect association).

2.4.2. Multinomial Logistic Regression

Multinomial logistic regression (MLR) [34,35] was used to model transport mode choice across six options: commercial motorcycles (bike), private car, bus, walking, shared taxi, and ride-hailing service (Yango). MLR extends binary logistic regression by estimating a separate binary logistic model for each category relative to a baseline reference category.

The model formulation is presented in equation below:

$$U_{mi} = ASC_m + \beta_{m1}\gamma_{mi1} + \beta_{m2}\gamma_{mi2} + \cdots + \beta_{mk}\gamma_{mik} \quad (2)$$

where:

- i: individual
- m: transport mode
- U_{mi}: is the net utility function for mode m, for individual i
- ASC_m: is the alternative specific constant for mode m
- $\gamma_{mi1}, \ldots, \gamma_{mi2}$ are the k number of attributes for mode m for individual i.
- $\beta_{m1}, \ldots, \beta_{m2}$ are the k number of coefficients of mode m associated with the independent variables.

For identification, one category is designated as the reference category. In this study, "Bike" (commercial motorcycles) was selected as the reference category. The coefficients are typically exponentiated to obtain odds ratios (ORs). An OR greater than 1 indicates that a one-unit increase in the predictor increases the odds of choosing that mode over the reference mode. Model fit was evaluated using the Likelihood Ratio Test and pseudo R-square measures.

2.4.3. Cluster Analysis

Cluster analysis was employed to segment the female respondent population into distinct groups based on mobility profiles, demographics, and safety experiences. The Partitioning Around Medoids (PAM) algorithm [36] was selected because it minimizes the sum of dissimilarities between objects and cluster centers (medoids) rather than minimizing squared Euclidean distances, making it less sensitive to extreme values and more robust to outliers. PAM operates on a dissimilarity matrix based on Gower distance for mixed data types [37] and can accommodate various distance measures suitable for mixed data types. The dataset contained a mix of variable types: continuous (trip complexity), ordinal (income, perceived security), and categorical (mode choice, harassment victimization). The optimal number of clusters was determined using the silhouette method [38], which

measures the cohesiveness of an object relative to its own cluster compared to other clusters. The average silhouette width was computed for solutions ranging from k = 2 to k = 10. A six-cluster solution yielded the highest average silhouette coefficient among solutions with more than three clusters (average silhouette width = 0.42), indicating the most cohesive within-cluster groupings and the clearest between-cluster separation given the data structure. Cluster solutions from k = 4 to k = 8 were subsequently examined for substantive interpretability, specifically whether the resulting profiles corresponded to theoretically meaningful and policy-relevant groupings of female transport users. The six-cluster solution was preferred because it produced distinct and interpretable profiles that varied meaningfully along the key dimensions of transport mode, income level, age, harassment exposure, and safety perception. Solutions with fewer clusters merged groups with substantively different vulnerability profiles, reducing analytical precision, while solutions with more clusters produced profiles that were statistically distinguishable but not substantively distinct from one another, reducing practical utility. It is acknowledged that the cluster solution constitutes a data-driven classification rather than a confirmatory typology, and the identified profiles should be understood as descriptive analytical constructs. External validation through replication in other cities or with independent samples would strengthen confidence in the generalizability of the typology.

2.5. Ethical Considerations

The research protocol was designed to ensure ethical treatment of participants. Informed consent was obtained from all survey respondents, with clear explanation of the study's purpose, voluntary nature of participation, and confidentiality measures. No personally identifiable information was collected. Given the sensitive nature of harassment experiences, the questionnaire was designed to allow participants to skip questions they were uncomfortable answering. The research received institutional support from the National Advanced School of Public Works, Yaoundé.

3. Results

3.1. Socio-Demographic Profile of Respondents

The survey included 345 participants. Table 1 presents the detailed socio-demographic characteristics of the sample. The age distribution skewed young, with nearly two-thirds of respondents aged 18–24 years and an additional 30.1% aged 25–34 years. Economic vulnerability characterized the sample, with over 71% of respondents reporting monthly household incomes below 100,000 FCFA (approximately USD 185). Despite economic constraints, educational attainment was relatively high, with 35.9% of respondents having completed postgraduate degrees and 31.9% having superior-level education. Vehicle ownership was extremely limited, with 90.1% of respondents reporting no vehicle ownership, necessitating heavy reliance on public or informal transport.

Table 1. Socio-demographic characteristics of respondents.

Characteristic	Category	Frequency	Percentage
Education Level	Secondary	3	0.9%
	Superior	110	31.9%
	HND	28	8.1%
	Bachelor	80	23.2%
	Postgraduate	124	35.9%
	Total	*345*	*100%*
Age Group	18–24 years	221	64.1%
	25–34 years	104	30.1%
	35–44 years	13	3.8%
	45–54 years	2	0.6%
	55–64 years	4	1.2%
	>65 years	1	0.3%
	Total	*345*	*100%*
Vehicle Ownership	No Vehicle	311	90.1%
	Owns Vehicle	34	9.9%
	Total	*345*	*100%*
Monthly Household Income (FCFA)	<100,000	248	71.9%
	100,000–200,000	47	13.6%
	200,000–300,000	30	8.7%
	300,000–400,000	7	2.0%
	400,000–500,000	7	2.0%
	>500,000	6	1.7%
	Total	*345*	*100%*

3.2. Transport Mode Usage and Mobility Patterns

Transport mode usage patterns indicated a strong dependence on informal and active transport modes among women in Yaoundé. Walking was the most reported mode, used by 62% of respondents daily, highlighting the importance of pedestrian mobility and adequate pedestrian infrastructure. Informal motorized transport also plays a key role, with 57% of respondents using commercial motorcycles (bikes) due to their flexibility in navigating congestion and poorly connected road networks. Taxi services (shared and private) were used daily by 46% of respondents, demonstrating their importance as an intermediate transport option. In contrast, the use of formal or private modes was limited: private cars were used by 14% of respondents, buses by 8%, and ride-hailing services such as Yango by 4%, suggesting limited accessibility and affordability of formal transport alternatives.

Trip purposes were highly diverse, reflecting the complex mobility patterns of women. The most common purposes included education or study (93%), shopping and household errands (90%), and visiting friends or family (73%), while 55% of respondents reported work-related trips and 38% reported childcare or escorting children. This multiplicity often leads to trip-chaining, where multiple destinations are visited within a single outing, increasing travel complexity, travel time, and reliance on flexible transport modes.

3.3. Harassment Experiences and Safety Perceptions

A total of 334 respondents (96.8%) reported experiencing some form of harassment while using road transport in Yaoundé, indicating that harassment is a pervasive feature of women's daily mobility rather than an isolated occurrence.

The most reported form of harassment was unwanted looks or staring (33%), followed by theft (29%), verbal harassment or inappropriate words (18%), inappropriate gestures (13%), and sexual assault (7%). Although some forms such as staring may appear less severe than physical assault, their persistent nature creates a climate of discomfort, surveillance, and psychological stress that can significantly constrain women's sense of safety and freedom in public spaces.

Harassment was reported across all transport modes, with the highest occurrence among motorcycle users (72%), followed by pedestrians (67%), taxi users (59%), and even private car users (50%). While some specific forms of harassment appear numerically lower, this may reflect underreporting due to normalization of harassment, fear of stigma, or reluctance to disclose sensitive experiences, particularly in survey contexts.

The reported frequencies further highlight the seriousness of the issue: 17% experienced harassment "very often" (multiple times a week), 25% "often" (a few times a month), 35% "rarely" (a few times per year) and 23% "very rarely". This indicate that for many women harassment is a recurring and routine aspect of everyday travel.

Perceived security was correspondingly low. When asked to rate their sense of security while using transport, only 9 respondents (2.6%) reported feeling "secure" or "very secure", while 336 (97.4%) reported feeling "not secure", "somewhat insecure", or "very insecure". This profound insecurity pervades all demographic groups and transport modes, indicating a systemic failure of transport systems and public spaces to ensure women's safety.

3.4. Association Analysis Results

Chi-square tests of independence revealed several significant associations between socio-demographic factors and mobility or safety variables. Table 2 presents the results of selected chi-square tests.

Significant associations were found between age and both harassment frequency ($\chi^2 = 55.059$, $p < 0.001$, $V = 0.231$) and harassment type ($\chi^2 = 62.458$, $p < 0.001$, $V = 0.190$). Younger women (18–24) reported more frequent harassment, particularly staring and verbal harassment, while older women reported different harassment profiles, with theft being more prominent. This suggests age-specific vulnerability patterns requiring differentiated interventions. In terms of age and mode choice regarding perceived accessibility, significant associations were only observed for walking and motorcycles, while other mode choices (not shown in Table 2) had p values greater than 0.05 and did not exhibit significant associations.

Income was significantly associated with transport mode choice ($\chi^2 = 51.641$, $p = 0.001$, $V = 0.173$). Higher-income women were more likely to use private cars or ride-hailing services, while lower-income women disproportionately relied on walking, motorcycles, and shared taxis—the modes associated with highest harassment rates. This pattern indicates that economic constraints are associated with greater reliance on transport modes that also carry higher harassment exposure Education level showed a strong association with access to private cars ($\chi^2(20) = 57.051$, $p < 0.001$, Cramér's $V = 0.203$).

Critically, no significant association was found between mode choice and perceived infrastructure safety ($\chi^2 = 18.862$, $p = 0.220$) or security ($\chi^2 = 25.480$, $p = 0.184$). This finding is particularly important: it suggests that

women may not perceive any transport mode as safer than others, indicating that practical constraints (cost, availability) rather than safety considerations often drive mode choice.

Table 2. Chi-square test results for key variable associations.

Variable 1	Variable 2	χ^2 Statistic	Df	*p*-value	Cramér's V	Interpretation
Age	Accessibility (Walking)	39.237	20	0.006	0.169	Significant association
Age	Accessibility (Bike)	39.592	20	0.006	0.169	Significant association
Age	Harassment Frequency	55.059	15	<0.001	0.231	Significant association
Age	Harassment Type	62.458	30	<0.001	0.190	Significant association
Age	Mode Choice	37.683	25	0.050	0.148	Marginally significant
Income	Mode Choice	51.641	25	0.001	0.173	Significant association
Education	Accessibility (Private Car)	57.051	20	<0.001	0.203	Significant association
Mode Choice	Perceived Safety (Infrastructure)	18.862	15	0.220	0.135	No significant association
Mode Choice	Perceived Security (Infrastructure)	25.480	20	0.184	0.136	No significant association

3.5. Multinomial Logistic Regression: Determinants of Mode Choice

Multinomial logistic regression was performed with transport mode choice as the dependent variable (six categories) and "Bike" (commercial motorcycles) as the reference category. Independent variables included age, education level, employment status, and income. The model demonstrated significant overall fit, with a Likelihood Ratio Chi-Square of 62.051 ($p < 0.001$). However, pseudo R-square values were modest (Cox & Snell $R^2 = 0.165$, Nagelkerke $R^2 = 0.176$, McFadden $R^2 = 0.066$), suggesting that unmeasured factors also substantially influence mode choice. Table 3 presents the detailed regression results.

Table 3. Multinomial logistic regression results for mode choice (Reference: Bike).

Parameter	Predictor	B-Coefficient	Std. Error	*p*-Value	Exp(B) (Odds Ratio)
Private Car	(Intercept)	−2.092	1.345	0.1200	0.123
	Age	0.730	0.298	0.0142	2.076
	Education	−0.112	0.136	0.4115	0.894
	Employment	−0.376	0.227	0.0986	0.687
	Income	0.508	0.152	0.0008	1.662
Bus	(Intercept)	−42.756	0.428	0.0000	0.000
	Age	0.787	0.668	0.2382	2.198
	Education	0.803	0.588	0.1716	2.233
	Employment	10.711	1.284	0.0000	44,858.26
	Income	0.483	0.401	0.2286	1.621
Walk	(Intercept)	−0.245	1.903	0.8977	0.783
	Age	0.123	0.482	0.7985	1.131
	Education	−0.167	0.184	0.3661	0.847
	Employment	−0.409	0.333	0.2198	0.665
	Income	−0.031	0.306	0.9201	0.970
Taxi	(Intercept)	−0.503	1.115	0.6518	0.605
	Age	0.719	0.261	0.0058	2.052
	Education	−0.311	0.106	0.0032	0.732
	Employment	−0.059	0.204	0.7722	0.943
	Income	0.175	0.154	0.2559	1.191
Yango	(Intercept)	−2.365	2.562	0.3560	0.094
	Age	0.517	0.576	0.3691	1.678
	Education	−0.387	0.242	0.1100	0.679
	Employment	0.154	0.495	0.7555	1.167
	Income	0.238	0.304	0.4337	1.268

For private car use versus commercial motorcycle use, age emerged as a significant predictor with an odds ratio of 2.076 (95% CI: 1.153–3.737, $p = 0.014$), meaning that for each one-unit increase in age category, the odds of using a private car increase by 107.6%. Income also demonstrated a strong, highly significant effect, with an odds ratio of 1.662 (95% CI: 1.246–2.217, $p < 0.001$), indicating that for each one-unit increase in income level, the odds of using a private car increase by 66.2%. This strong, highly significant effect demonstrates that economic resources are significantly associated with perception of access to safer (perceived), more comfortable transport. The implication is that economic inequity directly translates into mobility inequity.

For taxi use versus commercial motorcycle taxi use, age again proved significant, with an odds ratio of 2.052 (95% CI: 1.231–3.421, $p = 0.006$), suggesting older women are more than twice as likely to choose taxis over motorcycles. This may reflect discomfort with motorcycle riding (requiring balance and physical agility) or higher safety concerns about motorcycle crashes. Paradoxically, education level showed a negative association with taxi use relative to motorcycles, with an odds ratio of 0.732 (95% CI: 0.598–0.897, $p = 0.003$). This counterintuitive finding may be explained by higher-educated women having better access to private vehicles (as shown in the association analysis), thus reducing reliance on taxis.

For bus use versus commercial motorcycle taxi use, employment status demonstrated an exceptionally large coefficient and odds ratio (OR = 44,858, $p < 0.001$). This extreme odds ratio (likely inflated due to small cell sizes) suggests that buses are used almost exclusively by employed women, possibly for longer, more regular commutes where bus routes are available. The extremely large OR should be interpreted with caution, as it may indicate quasi-complete separation in the data. For walking versus commercial motorcycle taxi use, no predictors reached statistical significance. This suggests that walking is a necessity across all demographic groups, not a choice driven by socio-economic factors. Women walk because they must, not because of preferences shaped by age, education, or income.

3.6. Cluster Analysis: Six Distinct Mobility Profiles

Cluster analysis using the PAM algorithm identified six distinct clusters of female transport users. The silhouette method indicated the highest average silhouette width at k = 6 (average silhouette = 0.42), suggesting reasonably well-separated and cohesive clusters. Table 4 presents the consolidated profile of each cluster.

Table 4. Cluster profiles of female transport users in Yaoundé.

Variable	Breakdown	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Age	<18	4.2%	0.0%	1.7%	0.0%	0.0%	3.1%
	18–24	62.5%	74.3%	72.9%	43.9%	47.5%	68.8%
	25–34	33.3%	23.8%	25.4%	43.9%	42.5%	23.4%
	35–44	0.0%	2.0%	0.0%	10.5%	7.5%	3.1%
	45–54	0.0%	0.0%	0.0%	1.8%	0.0%	1.6%
	>65	0.0%	0.0%	0.0%	0.0%	2.5%	0.0%
Income	<100 k	83.3%	86.1%	69.5%	45.6%	65.0%	75.0%
	100–200 k	8.3%	6.9%	18.6%	21.1%	17.5%	12.5%
	200–300 k	0.0%	5.0%	8.5%	17.5%	15.0%	6.2%
	300–400 k	8.3%	1.0%	0.0%	3.5%	0.0%	3.1%
	400–500 k	0.0%	1.0%	0.0%	7.0%	0.0%	3.1%
	>500 k	0.0%	0.0%	3.4%	5.3%	2.5%	0.0%
Perceived Security	Not Secure (0)	100%	98.0%	94.9%	100%	92.5%	98.4%
	Secure (1)	0.0%	2.0%	5.1%	0.0%	7.5%	1.6%
Harassment Victim	No	4.2%	2.0%	6.8%	0.0%	0.0%	3.1%
	Yes	95.8%	98.0%	93.2%	100%	100%	96.9%
Mode Choice	Walk	87.5%	0.0%	0.0%	0.0%	0.0%	0.0%
	Motorcycle	0.0%	99.0%	89.8%	0.0%	0.0%	0.0%
	Bus	0.0%	1.0%	1.7%	1.8%	0.0%	3.1%
	Private car	0.0%	0.0%	0.0%	98.2%	0.0%	0.0%
	Taxi	0.0%	0.0%	0.0%	0.0%	100%	90.6%
	Yango	12.5%	0.0%	8.5%	0.0%	0.0%	6.2%

Cluster 1, "Vulnerable Female Pedestrian", comprised 24 women (7.0%) who were predominantly young (62.5% aged 18–24) from very low-income households (83.3% earning less than 100,000 FCFA). They relied almost exclusively on walking (87.5%) and faced universal insecurity (100%) and very high harassment rates (95.8%). Cluster 2, "Young Women on Motorcycles", was the largest cluster, consisting of 101 women (29.6%). These respondents were the youngest (74.3% aged 18–24) with the lowest incomes (86.1% earning less than 100,000 FCFA). They relied almost entirely on commercial motorcycle taxis (99%) and reported the highest harassment rate at 98% and near-universal insecurity (98%). Cluster 3, "Women on Motorcycles", included 59 women (17.3%) with similar demographics. They also used commercial motorcycle taxis (89.8%) and reported high rates of harassment (93.2%) and insecurity (94.9%).

Cluster 4, "Insecure Female Motorist", comprised 57 women (16.7%) exhibiting a more diverse age and income distribution. Nearly all used private cars (98.2%). Critically, this cluster reported universal harassment (100%) and insecurity (100%), despite having access to private vehicles. Cluster 5, "Female Taxi Users", included

40 women (11.7%) ranging from young to middle age with low to medium incomes. They used taxis exclusively (100%) and reported universal harassment (100%) and high insecurity (92.5%). Cluster 6, "Multi-Modal Women", comprised 64 women (18.8%) who were young and low-income, utilizing multiple modes of transport, with taxis being the dominant choice (90.6%). They reported very high rates of harassment (96.9%) and insecurity (98.4%).

A critical cross-cutting insight emerged: harassment rates ranged from 93.2% to 100% across all six clusters, with no cluster reporting substantively lower victimization. This universality demonstrates that harassment is a systemic, mode-independent phenomenon rooted in societal gender norms rather than specific transport contexts.

3.7. Infrastructure Assessment Results

The comprehensive infrastructure audit of road sections across 17 key road segments reveals systematic disparities in safety performance that create significant mobility barriers for women and other vulnerable road users. The evaluation employed a standardized methodology across seven key infrastructure components: pavement quality, sidewalk provision, physical separation systems, vertical signage, horizontal markings, street lighting, and accessibility features. The findings demonstrate profound inequities in infrastructure provision that disproportionately affect women's safe access to urban spaces, particularly those traveling with children, elderly family members, or engaging in care-related mobility patterns that rely heavily on walking and public transport.

The analysis identifies critical infrastructure deficiencies that specifically constrain women's mobility and safety. Over half of the assessed sections lack any street lighting infrastructure, creating hazardous conditions that severely limit women's safe movement during evening and night hours—a critical barrier for women working non-traditional hours, accessing healthcare, or performing care responsibilities after dark. The majority of sections show complete absence of horizontal signage, including pedestrian crossings, which is particularly problematic for women traveling with children who require clearly marked safe crossing points. Approximately half of the locations operate without traffic control systems or vertical signage, creating unpredictable and unsafe environments that discourage women's independent mobility. Most concerning is the widespread reliance on minimal physical separation between vehicular traffic and pedestrians, with most locations using only floor markings rather than robust raised sidewalks or barriers—a deficiency that heightens perceived and actual safety risks for women pedestrians who constitute the majority of walking trips in the city.

The evaluation also revealed near-complete absence of accessibility features such as tactile paving, wheelchair-accessible crossings, and proper sidewalk widths, creating additional barriers for women traveling with strollers, accompanying elderly relatives, or managing mobility challenges. The poor quality or complete absence of sidewalks in many sections forces women pedestrians to share road space with vehicular traffic, increasing exposure to both traffic accidents and gender-based safety concerns. Additionally, the lack of designated and well-lit public transport stops in most locations creates unsafe waiting environments, particularly affecting women who depend on public transport for work, education, and care-related travel. These systematic infrastructure gaps reinforce gender-based mobility inequities by limiting women's safe access to employment, education, healthcare, and social opportunities, thereby restricting their economic participation and overall quality of life in the urban environment.

4. Discussion

This study reveals a profound and systemic failure of the urban transport system in Yaoundé to meet the mobility and safety needs of women. The findings demonstrate that harassment and insecurity are near-universal aspects of women's daily travel experiences, irrespective of age, income level, education, or transport mode used. With 96.8% of respondents reporting harassment victimization and 97.4% reporting feeling insecure, these are not isolated incidents but defining features of the gendered transport landscape in Yaoundé. The results challenge several commonly held assumptions about transport safety and provide critical evidence for policy reform.

A central finding is what we term the "paradox of choice without safety": women in Yaoundé have access to multiple transport modes—walking, commercial motorcycles, taxis, buses, private cars, and ride-hailing services—yet none provides adequate safety. The cluster analysis identified six distinct user profiles, yet harassment rates across all clusters ranged from 93% to 100%. Most strikingly, Cluster 4 (Insecure Female Motorist), comprising women with access to private vehicles—traditionally considered the safest mode—reported 100% harassment and 100% insecurity. This finding fundamentally challenges the individual-level, market-based solution often proposed in transport discourse: that women can achieve safety by "choosing" safer modes or purchasing private vehicles. The data indicate that vehicle ownership is not associated with the elimination of harassment or improvement in the perception of insecurity. Women in private cars still experience unwanted attention at traffic lights, harassment during breakdowns or refueling stops, and pervasive anxiety about using public parking facilities or driving at night. The problem is not primarily the mode of transport but the broader

societal context in which all mobility occurs, one characterized by normalized gender-based violence and inadequate enforcement of laws protecting women's safety in public spaces [9,19]. The chi-square analysis further supports this interpretation, as mode choice was not significantly associated with perceived infrastructure safety ($p = 0.220$) or security ($p = 0.184$). Women do not perceive any available mode as safer than others. Consequently, mode choice is associated with practical constraints, namely affordability, availability, and trip requirements, rather than safety optimization. Lower-income women representing Clusters 1, 2, 3, and 6 are trapped between the options considered cheapest (walking and commercial motorcycle taxis) and the ones considered more expensive but still unsafe alternatives (taxis), with no pathway to secure mobility within their economic means.

The multinomial logistic regression results quantify the stark relationship between economic resources and transport access. For each unit increase in income level, the odds of using a private car instead of a commercial motorcycle increase by 66.2% (OR = 1.662, $p < 0.001$). While vehicle ownership does not guarantee safety, it does provide autonomy over travel timing, route selection, and avoidance of crowded public spaces; all factors which can mitigate, (though not eliminate) exposure to harassment. The concentration of the lowest-income women in Clusters 1 and 2 (pedestrians and motorcycle users with 98–100% harassment rates) reflects how economic deprivation is associated with heightened safety risk. This economic stratification of transport access is exacerbated by the informal nature of the transport system in Yaoundé. Formal public transport with regulated fares, published routes, and accountability mechanisms is virtually absent. Instead, women must navigate a fragmented market of informal operators whose services are neither standardized nor monitored for safety. The absence of fare regulation means transport costs can consume a disproportionate share of household budgets: low-income women in our sample (71.9% earning <100,000 FCFA/month) may spend 20–30% of income on transport, forcing impossible trade-offs between mobility and other essential needs like food or children's education [15,39]. International evidence demonstrates that investment in formal, affordable public transport—such as Bus Rapid Transit (BRT) systems with dedicated women-only compartments, well-lit stations, and security personnel—can significantly improve women's access to safe mobility [7,40]. However, Yaoundé has yet to translate planning into substantial infrastructure investment or regulatory reform. The persistent reliance on informal modes perpetuates the mobility-inequality nexus, where the poorest women bear the highest safety risks.

Clusters 1, 2, 3, and 6, comprising 74.7% of the female sample, share common characteristics: young age (predominantly 18–24 years), low income (<100,000 FCFA/month), and reliance on walking, motorcycles, or taxis. These women face what can be characterized as an "inescapable mobility trap". Their economic constraints preclude access to private vehicles (the only mode offering autonomy, if not safety), yet the available alternatives, walking (Cluster 1) or motorcycles (Clusters 2 and 3), are associated with the highest rates of harassment (96–98%) and accident exposure. Motorcycles, in particular, present a complex risk profile. They are the fastest and most affordable motorized option for short trips, making them indispensable for time-constrained women juggling employment and caregiving responsibilities. However, motorcycles carry high crash risk and expose female passengers to harassment from drivers, who operate in largely unregulated markets with minimal accountability [41]. Our findings indicate that 98–99% of commercial motorcycle users experience harassment, yet 46.6% of the sample (Clusters 2 and 3 combined) rely heavily on this mode because no safer, affordable alternative exists. The situation is even more dire for Cluster 1 (Vulnerable Female Pedestrian), the poorest group who walk because they cannot afford even motorcycles. These women face universal insecurity (100%) and the compounded dangers of traffic collisions (walking on roads without sidewalks), crime (walking through poorly lit areas), and sexual harassment. Their mobility is not a choice but a necessity imposed by extreme poverty, and every trip involves navigating life-threatening hazards. The concept of the mobility trap extends beyond immediate safety concerns to encompass long-term opportunity constraints. Women who cannot safely or reliably access employment, education, or healthcare face restricted economic mobility and reduced lifetime earnings [42]. The 38% of respondents who reported difficulty traveling with children face particular challenges in accessing childcare, limiting their ability to work full-time. Thus, transport insecurity perpetuates cycles of poverty and gender inequality across generations.

The infrastructure audit documented severe, widespread deficiencies: several portions of audited sites lacked functional street lighting, crosswalk markings, and vertical signage These deficiencies represent a form of structural violence, the systematic failure of urban systems to provide basic safety infrastructure, which disproportionately affects vulnerable populations [43,44]. The concept of "dark zones", entire intersections without lightingis particularly salient. These spaces become, in effect, no-go areas for women after dusk, constraining their mobility and economic participation. Women who work evening shifts or must travel at night face stark choices: risk assault by traveling through unlit areas, pay for expensive taxi services they cannot afford, or simply not travel. The absence of marked crosswalks and signage creates uncontrolled environments where pedestrians have no formal right-of-way and must negotiate passage informally. Such negotiations disadvantage

women, who may be burdened with children or goods and who face harassment or intimidation from drivers. These infrastructure deficiencies are not evenly distributed: many of the audited intersections are located in lower-income neighborhoods where Clusters 1, 2, and 3 disproportionately reside, creating compounded vulnerability for women with the fewest resources. The policy implications are clear: infrastructure investment is a fundamental requirement for gender equity [4,45].

The significant association between age and both harassment type ($\chi^2 = 62.458$, $p < 0.001$) and harassment frequency ($\chi^2 = 55.059$, $p < 0.001$) reveals that vulnerability is not uniform across women but differentiated by life stage. Younger women (18–24 years), who constitute 64.1% of the sample, reported higher frequencies of verbal harassment and unwanted staring, forms of harassment rooted in the sexualization of young women's bodies in public space. Older women reported relatively higher incidences of theft and physical obstruction, possibly reflecting perceptions of them as less able to resist or pursue assailants. This finding underscores the importance of intersectional analysis in transport research [1,4,22,23]. Women are not a homogeneous category; their experiences of mobility and safety are shaped by the intersection of gender with age, economic status, disability, ethnicity, and other social identities. Younger, lower-income women (Clusters 2 and 3) face compounded disadvantage, while older, higher-income women with vehicle access (Cluster 4) still face universal harassment, demonstrating that privilege on one axis does not eliminate vulnerability on another. Policy interventions must be tailored to these differentiated needs. For example, age-targeted safety campaigns might address the specific harassment patterns faced by young women (e.g., anti-catcalling campaigns in schools and universities), while infrastructure improvements (e.g., accessibility features, well-lit bus stops) would particularly benefit older women and those with mobility impairments. A one-size-fits-all approach will fail to address the diversity of women's experiences.

The findings challenge simplistic applications of travel behavior theories like the Theory of Planned Behavior [25,26]. While TPB posits that transport mode choice is a function of attitudes, subjective norms, and perceived behavioral control, our results show that "choice" is deeply constrained. For the 90.1% of respondents without vehicle ownership and the 71.9% with incomes below 100,000 FCFA/month, the range of feasible modes is extremely limited. Their "perceived behavioral control" is near-zero; they must use whatever mode is affordable, regardless of safety concerns. Moreover, the lack of association between mode choice and perceived safety ($p = 0.220$) suggests that attitudes about safety do not significantly shape behavior because no safe option exists. Traditional behavioral models assume actors have genuine alternatives from which to choose based on preferences; in Yaoundé's context, women navigate a landscape of constrained non-choices. This insight aligns with feminist critiques of rational choice theory, which argue that such models obscure structural constraints and power inequalities that limit agency [9,14,46].

The multinomial logistic regression model, while statistically significant, explained only a modest portion of variance in mode choice (Pseudo R^2 values 0.066–0.176). This suggests that unmeasured factors—such as specific trip distance, time of day, weather conditions, presence of children, and route-specific safety concerns substantially influence mode choice. Future research incorporating trip-level (rather than person-level) data and qualitative methods (e.g., travel diaries, GPS tracking) could capture these contextual factors.

It must be emphasized that, given the cross-sectional nature of this study, all reported relationships are associational rather than causal. The observed associations between income, mode choice, and harassment exposure are consistent with the theoretical frameworks employed but do not establish the direction of causality or rule out the influence of confounding variables. Longitudinal or experimental research designs would be required to draw causal conclusions and to test the predictive validity of TRA- and TPB-informed constructs in this context.

5. Recommendations

Based on the findings, we propose four comprehensive, multi-level recommendations to improve women's mobility and safety in Yaoundé:

(1) Implement Comprehensive Infrastructure Improvements Prioritizing Women's Safety. Launch an immediate program to install functional street lighting at intersections currently unlit, using energy-efficient LED technology with backup power systems. Install marked crosswalks, vertical signage, and accessible sidewalks at all major intersections and transport corridors, with priority given to high-traffic locations near markets, schools, healthcare facilities, and transport terminals. Construct raised crosswalks and traffic calming measures to slow vehicular speeds in pedestrian-heavy areas. Ensure all infrastructure incorporates universal design principles including curb ramps and accessible pedestrian signals to accommodate pregnant women, and those traveling with young children. Rehabilitate the 71% of sidewalks showing quality or width deficiencies.

(2) Strengthen Regulation, Training, and Accountability for Informal Transport Operators. Develop and rigorously enforce minimum safety, accessibility, and service standards for all informal transport modes, particularly commercial motorcycles and shared taxis. Implement mandatory certification and training programs for all transport operators that include modules on gender sensitivity, anti-harassment protocols, safe driving practices, and passenger rights. Establish a transparent licensing system with enforceable penalties (fines, license suspension or revocation) for operators who violate safety standards or commit harassment. Support the formation of women-led transport cooperatives and provide seed capital, training, and technical assistance to increase women's economic participation in the transport sector while improving service quality.

(3) Establish Dedicated Safety Reporting and Enforcement Mechanisms with Gender-Sensitive Legal Frameworks. Launch a 24-h toll-free hotline and mobile application for real-time reporting of harassment and violence in transport settings, with GPS location tagging and integration with police dispatch systems for rapid response. Criminalize all forms of harassment in public spaces and transport settings with clear definitions and penalties and establish specialized fast-track courts for gender-based violence cases to ensure swift adjudication. Conduct regular, high-visibility enforcement operations targeting harassment and unsafe driving, with publicized outcomes to demonstrate accountability. Train all police officers on gender-sensitive investigation and response protocols and conduct public awareness campaigns challenging victim-blaming narratives.

(4) Mainstream Gender in All Transport Policy and Planning with Mandatory Data Collection and Community Participation. Mandate the collection, analysis, and publication of gender-disaggregated transport data including ridership, accident victimization, and harassment reports across all transport planning institutions. Establish gender-specific targets in the Yaoundé Urban Mobility Plan such as increasing women's perceived safety from 2.6% to 50% by 2030 and require gender impact assessments for all major transport infrastructure projects. Ensure women's meaningful participation (minimum 40% representation) on transport planning committees and advisory boards and allocate funding for capacity building of women's civil society organizations. Conduct biennial gender-disaggregated surveys to track changes in mobility patterns, harassment experiences, and safety perceptions, and institutionalize regular pedestrian safety audits to prioritize low-scoring locations for investment.

6. Conclusions

This study provides comprehensive, empirical evidence that women in Yaoundé face severe, systemic mobility challenges rooted in inadequate infrastructure, economic inequality, weak policy enforcement, and pervasive gender-based violence. Harassment is a near-universal experience (96.8% of respondents), occurring across all transport modes and demographic groups, demonstrating that it is not an isolated problem but a defining feature of the gendered urban landscape. The infrastructure gap characterized by widespread absence of street lighting, crosswalk markings, and adequate sidewalks creates objectively dangerous environments that disproportionately affect women, particularly those who are young, low-income, and reliant on walking or informal transport.

A critical finding is that women's transport mode choices are not "choices" in the conventional sense but constrained responses to economic necessity and pervasive safety threats. The lack of association between mode choice and perceived safety reveals that women do not perceive any available mode as safe; their decisions are dictated by affordability and practical constraints rather than safety optimization. This creates an "inescapable mobility trap" for low-income women, who must navigate between inexpensive but dangerous options (walking, motorcycles) with no pathway to secure, affordable mobility.

This study contributes to scholarship on gendered urban mobility in the Global South along several theoretical dimensions. It provides empirical grounding for the application of TRA and TPB in a context where transport choices are severely constrained by structural poverty and informality, settings in which traditional rational-choice behavioral models require significant qualification. The findings suggest that while attitudinal and normative factors do shape stated preferences, their explanatory power is substantially mediated by perceived behavioral control constraints, namely cost and physical access, a finding that supports calls in the literature for structurally informed extensions of behavioral transport theory. The study also advances intersectionality as an interpretive lens in transport analysis, demonstrating that gender-based transport disadvantage is not homogenous but is significantly differentiated by income level, age, and transport mode, producing distinct vulnerability profiles. The cluster analysis operationalizes this insight empirically, moving beyond aggregate statistics to reveal the heterogeneity of women's transport experiences. Methodologically, the integration of supply-side infrastructure audit data with demand-side survey data in a single analytical framework represents a contribution that remains

uncommon in Sub-Saharan African transport literature, enabling cross-referencing of physical infrastructure deficiencies with user-reported safety perceptions and mode choices

The findings carry several actionable implications for policy and practice. The infrastructure audit results, showing that 53% of audited sites lack adequate lighting and 70% lack marked crosswalks, provide urban transport planners with a clear and prioritizable investment agenda. Safety improvements at the 17 identified high-risk locations represent a minimum first step that should be integrated into Yaoundé's Urban Mobility Plan. The finding that over 96% of women using commercial motorcycles reported harassment underscores the urgent need for mandatory gender-sensitivity training, licensing requirements, and accountability mechanisms for informal transport operators. The income-disaggregated cluster analysis reveals that the most vulnerable women, specifically those in Clusters 1 and 2 comprising pedestrians and commercial motorcycle users, are disproportionately young and low-income, indicating that transport subsidies or safety-oriented interventions targeted at this demographic could yield significant welfare gains. More broadly, the study demonstrates that gender-responsive transport planning in African cities cannot rely on demand-side behavioral interventions alone: supply-side infrastructure reform and regulatory enforcement are prerequisites for meaningful improvement in women's mobility and safety.

Achieving gender-equitable transport in Yaoundé requires a transformative approach that integrates gender-sensitive planning, targeted infrastructure investment, robust regulatory reform, and community-level interventions. Isolated interventions will be insufficient. What is needed is a comprehensive, multi-sectoral strategy that addresses the physical, social, economic, and legal dimensions of women's mobility. The evidence presented in this study provides a foundation for action. The question now is whether decision-makers will prioritize gender equity in transport and commit the resources necessary to transform Yaoundé into a city where all women can move freely, safely, and with dignity.

This study has some limitations that should be acknowledged. The cross-sectional survey design precludes causal inference: while the regression and cluster analyses identify associations between socio-demographic characteristics and transport outcomes, they cannot establish the direction of causality or rule out the influence of confounding factors. Longitudinal or panel data designs would be better suited to tracking how women's mobility behaviors and safety experiences evolve over time in response to infrastructure changes or policy interventions. The sample was drawn from women aged 18 and above and may not fully represent the experiences of adolescent girls and elderly women, groups whose transport vulnerabilities may be qualitatively distinct and warrant purposive sampling in future research. The qualitative dimension of this study was limited to systematic infrastructure observation; no in-depth interviews or open-ended discussions were conducted to capture the experiential, affective, and cultural dimensions of women's mobility constraints. Studies incorporating phenomenological or participatory methods could yield richer insights into the lived experience of transport insecurity. The study is also geographically bounded to Yaoundé, and while the city was selected for its representativeness of rapidly urbanizing Francophone African cities, findings should be interpreted with caution before generalizing to urban contexts with different transport systems, cultural norms, or socio-economic structures. Future research should also consider formally operationalizing the TRA and TPB constructs through confirmatory factor analysis or structural equation modeling, and modeling statistical interaction effects between gender, income, and age to advance the intersectional analysis beyond the descriptive level achieved here

Author Contributions

S.K.F.: conceptualization, writing—original draft preparation; D.O.D.: methodology; N.I.N.: writing—original draft preparation; I.S.E.: data curation, investigation; S.L.F.: supervision; N.T.L.: writing—reviewing and editing; N.L.: validation. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

The study was approved by the Ethics Committee of the National Advanced School of Public Works, Yaoundé, with code MPT 500 on 23 April 2024.

Informed Consent Statement

Informed consent was obtained from all subjects involved in this study.

Data Availability Statement

The datasets generated and analyzed during this study are available from the authors upon request.

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Conflicts of Interest

The authors declare no conflicts of interest.

Use of AI and AI-Assisted Technologies

During the preparation of this work the authors used POE AI for language improvement. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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