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Appraising the nexus between influencers on the public transport choice by women commuters in South Africa

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ABSTRACT

Women represent the largest share of public transport users in developing countries, yet they face many barriers that limit their mobility. In South Africa, safety and security concerns and limited access to reliable transport reduce women's participation in the labor market. This study analysed 1,243 questionnaires collected from female commuters. The study developed a causal model of public transport choice by women. The casual model and the nexus between the influential factors, their sub-factors and women's choices were validated using structural equation modeling. The investigation found that women's inclusivity in public transport is extremely low, and that neither the public transport fleet nor transport facilities, provide for the needs of women commuters. Moreover, the study revealed that the rate of violence against women in South African public transport is significantly high, and that the majority of female passengers has experienced violence several times. The study deduces that public transport performance and socio-demographics are the main factors influencing women's choice of public transportation. Hence, by addressing gender-based violence, the level of use of public transport by South African women should increase significantly. In conclusion, the study recommends the need for immediate short-term remedies incorporating new technologies alongside long-term policy objectives to enhance the inclusivity of public transportation. The validated casual model can be used as a robust framework for improving the inclusivity and performance of public transport for women in Africa and diminishing gender violence.

Introduction

Achieving a viable and effective all-inclusive public transportation system is a universal challenge [1]. Public transport is vital part of urban fabric as most inhabitants depend on public transport for their social, economic, health, recreational, educational, and

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cultural activities. However, there is a general lack of effective, efficient, coordinated and reliable inclusive transportation systems for women in developing countries with little policy attention [2]. Transport experiences and needs vary between men and women, especially when it comes to personal safety and security, as well as frequency and affordability of transport. These differing needs and experiences are the result of societal gender roles in which women are disproportionately responsible for domestic work [3]. Inclusive public transportation access is essential if women, who comprise a large population in society, are to make positive contributions to their societies. However, women are sometimes relegated from active involvement in the transportation sector [4]. Accordingly, many scholars have attributed the worsening deficiencies in public transportation infrastructure and services to gender issues of inequality and social injustices. These constrain economic growth and perpetuate societal poverty [2,5,6]. The narrative is thus turning the tide towards more positive discourses and engagements that target equity, improved services, social wellbeing and economic growth. For instance, the World Bank and World Resources Institute 2018 conference on Transforming Transportation had a plenary session that particularly considered gender issues in transport for the first time in their 15-year annual event, where gender challenges in the transport sector were highlighted under the topic, "Transport is not gender-neutral". Similarly, awareness is giving rise to gender-targeted interventions that address gender disparities and promote inclusivity.

Gender and public transport are correlated to the socioeconomic disparities in the needs of both men and women in any given society. It thus becomes imperative to respond to the prolonged equality challenges that have existed for many decades in the transportation sector. These differences are primarily based on the gender-oriented division of labor that exists even within the family structures and the larger society [7]. Hence, both public and private stakeholders are seeking innovative solutions to overcome these challenges and create a more efficient and equitable transportation system. Diverse concepts and designs of gender-sensitive mechanisms are being employed to explore specific gender actions, needs and outcomes that can establish a clear path to incorporating a gender tailored operations' design, execution, and monitoring and evaluation [2].

South Africa is a country at war with itself where society wrestles with the historical effects of institutionalised discrimination. Women continue to bear the brunt of the deep trauma experienced during the Apartheid era, subjected to a culture of gender-based violence and femicide which is fueled by patriarchal social norms and belief systems and gender inequality [8]. Women using South African public transport are considered "open persons", subjecting them to unwanted attention, inappropriate physical contact, aggressive advances from strangers and other unsolicited invasive sexualised behaviours [9]. This study thus explores the transportation sector with a gender-sensitive lens to understand where South Africa stands on the global stage. The study not only explores women's challenges and inclusivity in the public transportation of developing countries but could also act as a guideline for public transportation stakeholders in other developing countries to foster a gender-sensitive transport that engenders a spike in the percentage of women using public transport as their primary mode of transport. Therefore, meeting women's transportation needs requires a paradigm shift with a gender lens that identifies modalities for setting appropriate policies that enable the necessary structural changes that address women's needs. Also, improved public transport infrastructures can have some positive ripple effects that will improve women's wellbeing and their access to goods and services, encourage their financial upliftment, promote economic growth, and other social benefits [10].

Therefore, this study aims to evaluate women's challenges and the inclusivity of South African public transport, by examining violence against women passengers in public transport and the level of women-oriented services provided by three modes of public transportation in South Africa. Furthermore, the study seeks to determine the extent of causality between the influential factors, namely socio-demographics, violence experiences, women-oriented public transport, and the public transport mode and time choice of women. South Africa is widely acknowledged as being an unequal country, despite well-designed and well-targeted policies, where a significant portion of the populace is engaged in a "snakes and ladders" type survival game. The persistent struggle with safety issues, gender discrimination, economic disparity, infrastructure challenges but to name a few [11], make it a pertinent case study to establish how these factors and challenges impact women's public transport choices using a developing country exemplar. To achieve this aim, the following research questions will be answered:

1. What is the level of women's inclusivity in three modes of public transport in South Africa?
2. What factors influence the choice of public transport mode by women?
3. How do these influencing factors impact upon women's decisions?

This research is one of the pioneer research studies modeling women's public transport choices using SEM, the developed and validated women's transport choice causal model. Previous studies and models in this field mainly tested the existing theories. In contrast, the current study uses SEM as an appropriate method for investigating the needs and challenges of women in various public transport modes. The current study presents several theoretical and practical implications for academics, practitioners and policy-makers. The findings of this study will provide valuable knowledge on the critical role and effectiveness of inclusivity of public transport for women. Practically, the results of this research will help understand and prioritize the women's needs and challenges for planning toward revolutionizing the current public transport to achieve inclusive public transport.

The paper unfolds as follows: Section 2 provides a literature review on the public transport in South Africa and women in public transport, Section 3 discusses the research methodology and development of the casual model, Section 4 presents the collected data and analysis; Sections 5 and 6 elucidate the findings and the discussion; and Section 7 offers the conclusion.

Literature review

Overview of inclusivity of public transport in South Africa

As in many other developing countries, population growth in South Africa is increasing at an exponential rate, which gives rise to a commensurate increase in transportation demand, [12]. However, as is common in other developing countries, there is a mismatch between limited supply and growing demand of public transport [13]. Poorly planned public transport systems prolong existing inequalities, exasperate environment concerns and contribute unnecessarily to complex urban and rural dilemmas [14]. Sustainable development requires an examination of social, environmental, economic, and political components in general necessary for overall progress [15]. The realization of (some of) the UN Sustainable Development Goal (SDG) 5 (Gender equality) targets rely on an efficient transport system to "secure equal participation and opportunities for leadership and universal access to sexual and reproductive rights" ([16]:7). Hence, women need public transportation that accommodates their social and economic needs in navigating through cities either as primary caregivers or members of the informal and formal labor force [17].

As one of the fast-growing emerging economies, South Africa is not exempted from affiliated challenges of inclusive public transport. According to the South African general household survey 2017, 91.4% of people in the lowest income earners in the country depend on public transport, 5.7% of this number used trains, 23.6% buses and 62.1% minibus taxis [18]. More women, particularly black African women, than men are likely to use public transport, particularly minibus taxis, however girl learners in both rural and urban areas were more likely to walk to an educational institution because public transport was deemed too expensive [16].

Road transportation is the most utilised mode of transportation for people and their goods in many parts of the developing world, particularly in sub-Saharan Africa and South Africa [19]. This is fundamentally so because other transportation modes like rail are not well developed in most parts of country. Accordingly, Kgamanyane [20] reported a lack of complementarity between rail and road transportation modes in South Africa. The road transport availability and reliability are better than the rail transport system in South Africa, making it the transport medium of choice for most passengers. For many years, the conditions of railway networks in South Africa have been deteriorating. Rail travel has "declined into insignificance" [21], with the number of commuters using rail transport dropping significantly between 2013 and 2020, from 10,0% to 1,8% for women commuters and from 15,5% to 4,5% for male commuters. While men and women train passengers are equally dissatisfied with the level of overcrowding in trains (84.5%), women are particularly dissatisfied with the walking time to stations as they felt vulnerable and unsafe (88.2%), and the frequency of trains running during peak and off-peak hours (79.7% and 79.1% respectively) [16]. Fenton et al. [22] report that the post-apartheid government has responded very poorly to the increasing mobility needs of low-income earners, especially women, who constitute the dominant numbers of South Africa's urban population.

The South African government has put various policies and strategies in place to enhance and promote public transport for many years. However, despite these attempts, the state has achieved very little to address this crucial issue sustainably, especially regarding gender-oriented and women's inclusivity in the public transportation sector [23]. Hence, the need to adopt gender-sensitive ideals for urban mobility policymakers and planners emerges as a challenging and impending task. Thomas [24] corroborates that despite the South African government initiatives, such as the minibus recapitalisation program in 2006, the publication of the public transportation strategy document in 2007, and the updating National Land Transport Transition Act in 2009, the meager changes that have been made are insufficient to enable South Africans to gain access to efficient, effective, safe, reliable and affordable public transportation. Thomas [24] admits that the provision of a riskless, accessible, and affordable public transport infrastructure is a fundamental prerequisite for the socioeconomic advancement of the South African population. The Department of Transport has acknowledged that the South African passenger transport system is "broadly inefficient and not sufficiently customer-focused and has poor levels of reliability, predictability, comfort and safety, with the exception of the Gautrain and the newly implemented bus rapid transit (BRT) systems in selected metropolitan municipalities" ([25]:8–2).

Post-apartheid South African society has continued to struggle with the paternalistic system [26]. This has been worsened by the apartheid laws at a time that enacted the various Bantu Acts. The Bantu Education Act and Bantu Labour Act on Black women aggravated their gender challenges [26]. The discrimination embedded in systemic structural differences contributed to greater percentage participation of men in economic activities and policy-making positions as against women who remained deprived of the opportunities. Even though the advent of democracy is now improving the narrative with the inclusion of women in governance and other economic activities, the transportation sector is yet to experience a significant transformation [27].

Public transportation is described as "an institution through which hegemonic masculinity is maintained" [28]. Women are still not as well represented in the operations, management and services, as they are as commuters. South African's lucrative minibus taxi industry generates about ZAR40 billion per annum from 200,000 taxis on the road [29], and is male-dominated, from owners to drivers, marshals, vehicle washers, mechanics, body shop personnel, vehicle parts and accessory sellers [30] with only an estimated 2.8% of minibus taxis owned by women [31], yet women make up 48% of the commuters using taxis [16]. As an aside, only 21.8% of women held a driver's licence in 2020 compared to men (40.1%) [16].

Though more women use buses than trains, women are also uncomfortable with the dearth of facilities at bus stops, over-crowding and found the off-peak service lacking [32]. The number of women who operate and/or drive the 19,000 buses which form part of the South African public transport system has slowly increased in recent years through determined efforts to address equality matters, with commuters reporting they feel safer with women bus drivers over short haul trips [9,21]. The number of women train drivers is estimated to be 25% nationally, however, their safety is a daily challenge [9]. It is argued that the improvement of the efficiency and effectiveness of the fragmented public transport system through innovative transport solutions is of major importance given its impact on vulnerable people and communities in South Africa [33].

Influencing factors on inclusive transport and women choice

In the contemporary world, where human identities and roles are defined by religious beliefs, cultural habits, and social standards founded on gender-oriented ideals, the choices people make on transportation mode and needs are also influenced by gender-affiliated variances in many ways. This is further demonstrated in the different mobility patterns for males and females, which are often informed not only by gender issues but also by personal experiences (such as harassment, violence) which can significantly influence user choices and modes of transportation [2,34].

Declarations that guarantee, support, and promote the equality and the empowerment of women include the Beijing Declaration and Platform for Action, the newly announced UN High-Level Panel on Women's Empowerment and importantly, the UN Declaration on Consequently, "Women inclusivity in transportation sector" has received particular attention in many discussions recently [35]. "Sustainable transportation facilitates mobility and is central to improving people's livelihoods and achieving other SDGs" ([16]:7). Public transport is therefore an essential service required to improve sustainable mobility to create opportunities that can improve livelihood and permit greater access to education and healthcare [15]. Access to secure, safe, affordable and reliable public transport is essential for South African women and girls, and although not explicitly enshrined in the South African Constitution, it is intrinsically linked to the right to freedom and security of the person, and the right to freedom of movement [9]. This would enable women to participate in economic activity, access education, health, and other important services, and positively contribute to sustainable development [36].

However, inclusive transportation gender issues are seldom addressed holistically in transportation planning and policy, just as gender policy agendas exclude transportation [2]. While "gender and transportation" discourse has been recently trending (as an evolving topic), no apparent systematic transportation strategy exists for gender inclusion in users' participation, professional training, system design and planning, services and equipment [2,6]. Hence, understanding how mobility is gendered is essential to finding ways of improving women's position and creating equity in the growing South African urban areas [37]. Establishing behavioural intention is the critical factor that influences public transport usage behavior with habit and satisfaction being important mediating factors [38].

Amongst other goals, the SDGs have recognized that safety and personal security must be guaranteed for all users of public transport [39]. Hence, public transport users make mode choices informed by these factors as well as a variety of other factors, which could be socially, economically and service-driven in accordance with the individuals' interests, responsibilities, habits, life cycle stage, income level, age and gender [34]. According to the Stats-SA [16] study of gender patterns in Transport, more women than men have undertaken day trips for religious and/or cultural and/or traditional and funeral reasons than men, who were more likely to have undertaken day trips for leisure or holiday and sporting activities.

Unfortunately, gender biases influence many facets of public life and decisions in South Africa. and women to continue to struggle with gender-discriminatory systems, structures and policies [40]. Furthermore, Martin [40] suggests that dismantling patriarchy and empowering women are mutually inclusive. Solutions are meant to equip women and challenge the status quo to become vital for the country's growth and prosperity. It is estimated that reducing the labor market's gender gap can boost the global economy of emerging markets by up to 14% of their GDP [41]. However, the global statistics demonstrate a male-dominated transport sector where women are inconspicuous, whether as decision-makers, suppliers or consumers [42], thus, making it even harder for them to express themselves and be heard. This status quo is worsened by the limited incentives for inclusivity of sector. Even when several initiatives have been launched in different quarters to enhance inclusivity that encourages women's influence and involvement, this problem persists, and masculine norms are sustained. A study done by Sánchez and González [43] indicates that women and men have different mobility needs and patterns, yet transport policies for most countries remain unrelentingly gender insensitive. Furthermore, women's participation in the economy at an equal rate to men's could increase up to 26% of the annual GDP [41]. In South Africa, women account for 34,2% of total population, compared to 44.6% of men who were deemed employed in the last quarter of 2022 [44]. The ideal is for all women (and men) to "achieve full and productive employment and decent work" by 2030 [45].

In addressing the issue of gender inequality, [46] reported that two leading schools of thought exist. "Essentialism", whose proponents believe that biological disparities exist between males and females. These disparities are rooted in their "essential" natures and so, inequality is not viewed through a social factors' lens, but rather through the lens of biological dispositions of "the male sex to dominate, exploit, and oppress the female sex.". Other theories, however, pay attention to "nurture" and how social structures influence human nature [46]. This shifts rational thinking from the fixed notion of unchanging biological factors toward social and external factors. As a result, global challenges such as poverty and gender inequality are viewed through a sociology lens, not biology.

ReliefWeb corroborates that despite recognizing that gender equality is a human right, women still constitute 70% of people living in poverty. As a result, feminist political thought has struggled with two fundamental dimensions to women's poverty liberation. First, "it analyses the institutions, processes and practices through which women have been subordinated to men; and second, it explores the most appropriate and effective ways in which this subordination can be challenged" [47].

Unfortunately, sexual harassment and assault against women on public transport is both an international and national phenomenon [17]. According to Fu and Juan [38], the dangers faced by women in public transportation are diverse and occurred in different location and time. South African women, like other women around the world, experience verbal harassment such as catcalling or verbal abuse, visual harassment such as men exposing themselves or physical harm or abuse such as groping, unsought touching, assault or rape [9,17,48]. Women are especially insecure and anxious when travelling on public transport alone and/or during off-peak hours in developing countries such as Asia and Africa. There are limited complaint mechanisms that women are aware of or trust when they experience threats to their safety, experience harassment or poor customer service [49].

In South Africa, research has indicated that women significantly use more time than men in providing care work services. In addition, women make multiple-stop trips when travelling between their homes and workplaces [34]. South African women are also

far more reliant on safe public transportation and public spaces related to public transport than men. The National Transport Master Plan (NATMAP) 2050 is an impressive blueprint to revitalize South Africa's transport industry [50], however, little or no mention is made about genderised transport priorities. This corroborates the a gap identified in literature globally which indicates that even when there has been a broad acknowledgement of inclusivity challenges for women in public transportation for so many years, there remains a fundamental lack of awareness and inclusion of the gender-sensitive policy and provision that can positively transform the transportation industry [17,34].

Modeling causality

Due to the complexity of selecting public transport modes by women, there is a need for research utilizing a systems approach to generate evidence that investigates the interlinked influential factors of inclusive transport and transport choice by women. Therefore, this paper considers the influential factors of inclusive transport and transport choice by women extracted from the literature (see Table 1). The study classified these influential factors under four constructs: sociodemographic of commuters, violence in public transportation, and women-oriented public transport and transport performance. The sociodemographic factors were theorised as consisting of age, income, occupational commuter, frequency of using the public transport and trip purpose. The violence factors include an abundance of experienced violence, location, time and type of experienced violence in public transport by women commuters. Based on the reviewed literature, the public transport performance was established as, accessibility, affordability, cleanliness, comfortability, flexibility, inclusivity, innovation, reliability, safety and security of public transport. Moreover, the public transport choice is evaluated through women's chosen mode of transportation and time of use.

Consequently, a conceptual framework was developed detailing the causality between the four constructs (sociodemographic, violence, women-oriented and performance) to transport choice of women commuters as shown in Fig. 1.

Six hypotheses are formulated below on the sociodemographic of commuters, violence, women-oriented transport and transport performance as independent constructs, directly influencing public transport choice (H1, H2, H3 & H4). Moreover, the violence and women-oriented constructs mediate the influence of transport performance on the transport choice (H5 & H6).

Based on the research questions and developed research model, the research is designed to test the following hypotheses:

H1: There is a relationship between the sociodemographic characteristics of women and choices made by commuters.

H2: There is a relationship between the level of gender-based violence and the public transport commuters choose.

H3: There is a relationship between the level of women-oriented public transport and the public transport commuters choose.

H4: There is a relationship between public transport performance and the public transport commuters choose.

H5: The level of gender-based violence mediates the relationship between transport performance and public transport commuters choose.

H6: The level of women-oriented public transport mediates the relationship between commuters' transport performance and their choice of public transport.

Research methods

A quantitative research design was adopted as the most appropriate approach to objectively model and verify the extant relationships among the influential factors and sub-factors. In addition, quantitative models allow for deductive testing, thus offering protection against the contradiction of bias and the generalization and replication of findings [54]. Accordingly, a physical questionnaire survey among women using public transport in October 2021 was undertaken to establish the influential factors on public transport choices by women in South Africa. The study's influential factors and sub-factors used in measuring the study constructs and its corresponding measurement scale are shown in Table 1.

The required data was obtained from the structured questionnaire survey distributed randomly among the female passengers above 18 years old of three modes of public transport, namely Train, Bus and Minibus at 15 major public transportation stations in Gauteng province during peak and off-peak hours. Since the population of women commuters using public transport is unknown, the minimum 385 data (recommended sample size for unknown population at confidence level of 95% and margin of error of 0.05) was targeted to collect from each public transport mode. The questionnaires were completed by 447 Train, 390 Bus and 406 minibus female passengers in Gauteng province in October 2021. Informed consent was obtained from all women participants involved in the study. The study was conducted in accordance with the Declaration of University of Cape Town and approved by Ethics Committee of the Faculty of

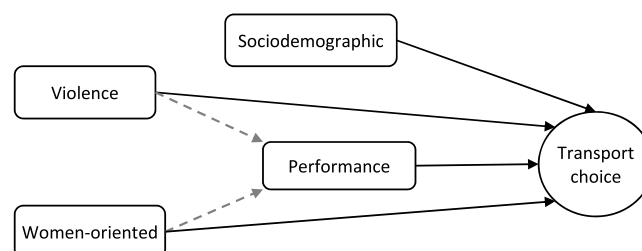


Fig. 1. Causal model of public transport choice by women.

Table 1
Influential factors and sub-factors of study.

Construct	Influencing factors	Source	Measurement Scale
Sociodemographic	Age	1, 2	Respondents were asked to indicate their sociodemographic parameters by answering the semi-structured questions.
	Frequency of trip	1, 2	
	Income	1, 2	
	Occupation	1, 2	
	Trip purpose	1, 2	
Violence	Frequency of use	1, 2, 3, 4, 5	Respondents were asked to indicate their violence experienced in public transport by answering the semi-structured questions.
	Location	1, 2, 3, 4, 5	
	Time	1, 2, 3, 4, 5	
	Type	1, 2, 3, 4, 5	
Women-oriented	Facilities	1, 2, 6, 7, 9, 10, 11, 12	Respondents were asked to evaluate the women-oriented public transport they used by answering the semi-structured questions.
	Vehicle	1, 2, 6, 7, 9, 10, 11, 12	
	Outside station	1, 2, 6, 7, 9, 10, 11, 12	
	Station	1, 2, 6, 7, 9, 10, 11, 12	
Transport performance	Accessibility	6, 9, 13, 14	Respondents were asked to indicate the transport performance they used by answering the semi-structured questions.
	Cleanliness	9	
	Comfortability	6, 9, 14	
	Affordability	6, 8, 12, 13, 14	
	Flexibility	6, 9, 13, 14	
	Inclusivity	6, 9, 13, 14	
	Innovation	6, 9	
	Reliability	6, 9, 13, 14	
	Safety	2, 6, 8, 9, 14	
Security	2, 3, 6, 8, 9, 14		
Transportation choice	Mode	13, 14	Respondents were asked to indicate their choice of mode and time of public transport by answering the semi-structured questions.
	Time	13, 14	

1: [26], 2: [34], 3: [17], 4: [38], 5: [51], 6: [52], 7: [35], 8: (Karla [6]), 9: [36], 10: [7], 11: [53], 12: [2], 13: [10], 14: (Asian Development [5]).

Engineering and Built Environment, University of Cape Town (Application Ref: 231,636 and 30 April 2021).

A total of 1243 valid completed questionnaires were collected from 15 major public transport stations in Gauteng. The collected data from each mode of public transport is larger than the minimum sample size recommended for the unknown population, with a 95% confidence level and $\pm 5\%$ margin of error (385) [55]. Each questionnaire consisted of four parts: Part 1 sought sociodemographic information about the female passengers and information about their trip. Part 2 sought information concerning personal security and the violence experienced in South African public transport. Part 3 sought information regarding their evaluation of women-oriented public transport, and finally, part 4 sought the assessment of the performance of public transportation.

The data collected was analysed using descriptive and inferential statistical techniques to determine the Arithmetic Mean, Relative Importance Index (RII) and Ranking of the study variables using IBM SPSS Statistics version 28. Path analysis and confirmatory factors analysis were conducted to quantify the relationships among multiple variables and estimate latent constructs, respectively. Structural

Table 2
Profile of participants.

Sociodemographic Sub-factors		Bus		Minibus		Train	
		%	Rank	%	Rank	%	Rank
Age	18–30	31%	1	28%	2	22%	2
	31–40	17%	3	30%	1	25%	1
	41–50	19%	2	21%	3	17%	4
	51–60	15%	5	11%	4	16%	5
	Above 60	17%	3	10%	5	19%	3
Occupation	Full time employee	19%	2	17%	3	17%	3
	Part time employee	12%	6	23%	1	15%	5
	Retired/ Pensioner	16%	3	11%	6	20%	1
	Self-employed	15%	4	18%	2	17%	3
	Student	12%	5	17%	4	14%	6
Income	Unemployed	26%	1	14%	5	18%	2
	Less than R3 500 per month	35%	1	12%	5	32%	1
	R3 501 to R7 500	25%	2	13%	4	18%	3
	R7 501 to R15 000	9%	4	20%	3	20%	2
	R15 001 to R30 000	22%	3	27%	2	13%	5
More than R30 000	8%	5	29%	1	17%	4	

equation modeling (SEM) was used to test the six hypotheses of the study. SEM is a multivariate technique that coheres networks of constructs to data with the capability to test and evaluate both direct and indirect effects of multivariate causal relationships. SEM was used to validate the causal relationship between the constructs, using the maximum likelihood estimate and estimated latent variables based on the correlated variations of the dataset [56,57].

Five analytical steps were utilized in SEM: model specification, identification, parameter estimation, evaluation, and modification. The model specification defines the hypothesized relationships among the influential factors. Model identification checks overall model fitness based on the fit indices for a single path coefficient test. The model evaluation assesses model performance, with quantitative indices calculated for the overall appropriacy of fit. Modification adjusts the model to improve model fitness. Finally, validation is the process of improving the reliability and stability of the model.

Results

Participant sociodemographic

Table 2 presents the sociodemographic analysis of the 1243 women who participated in the study.

While the largest group using minibus (30%) and train (25%) are between the ages of 31 years to 40 years, the younger generation, between 18 and 30 years of age, comprises the majority of bus users (31%). The employment status of female passengers shows that most bus and train commuters are unemployed, full-time employees or retired/pensioners. However, most minibus passengers are part-time employees, self-employed or full-time employees. Furthermore, the analysis of employment status shows that unemployed women predominantly use bus and train due to the lower travel cost of these two modes of public transport in South Africa. The result indicates that most of the women using the bus (35%) and train (32%) belong to low-income level, while the majority of high-income women (29%) use minibus, which is because of the higher cost of minibus compared to train and bus.

As indicated in Table 3, the trip information reflects the frequency of use of each mode and the trip purpose they embark on. Regarding the frequency of use, the majority of women use the train (34%) and bus (32%) daily, while the majority of women use the minibus (32%) several times a week. The primary purpose of the trip for women in South Africa is to go to the workplace in all three modes of public transport. The second reason for trips for commuters who selected bus and minibus, is going to educational institutions while the second reason of trip on the train, is taking children to school. Moreover, the analysis of the reason for the trip reveals that public transport is not the primary mode for other routine activities of women such as care trips and visits/leisure trips.

Gender based violence

Fig. 2 illustrates participants' frequency of experiencing violence in each mode of transport by RII. The rate of gender violence in South African public transport is very high, and most female commuters experience gender violence more than once. The overall bus violence rate (56%) is significantly higher than the minibus rate (53%) and train rate (46%), while the train performed slightly safer than the minibus.

The most common gender violence in bus and minibus modes are verbal assault and physical assault, 60% and 59% in buses, and 57% and 55% in minibuses, respectively. However, the most common gender violence reported on trains is mugging (52%) and stalking (48%).

Women-oriented public transport

The overall women-oriented condition of all three South African public transport modes is considerably low, 47% in minibus, 55%

Table 3
Participants' Trip details information.

Trip Sub-factors		Bus		Minibus		Train	
		%	Rank	%	Rank	%	Rank
Frequency of use	Daily	32%	1	27%	2	34%	1
	Several times a week	31%	2	32%	1	20%	4
	Several times a month	28%	3	25%	3	24%	2
	Several times a year	8%	4	16%	4	22%	3
Trip purpose	Educational institution	12%	2	15%	2	8%	7
	Usual workplace	29%	1	24%	1	16%	1
	Shops	5%	9	9%	5	9%	6
	Religious institutions	9%	6	7%	6	10%	4
	Visiting friends/relatives	7%	7	7%	6	8%	7
	Looking for work	9%	5	12%	3	12%	3
	Medical services	10%	3	7%	6	7%	9
	Taking children to school	10%	3	10%	4	13%	2
	Holiday/leisure	6%	8	6%	9	9%	5
	Welfare offices	2%	10	4%	10	6%	10
	Others	0%	11	0%	11	3%	11

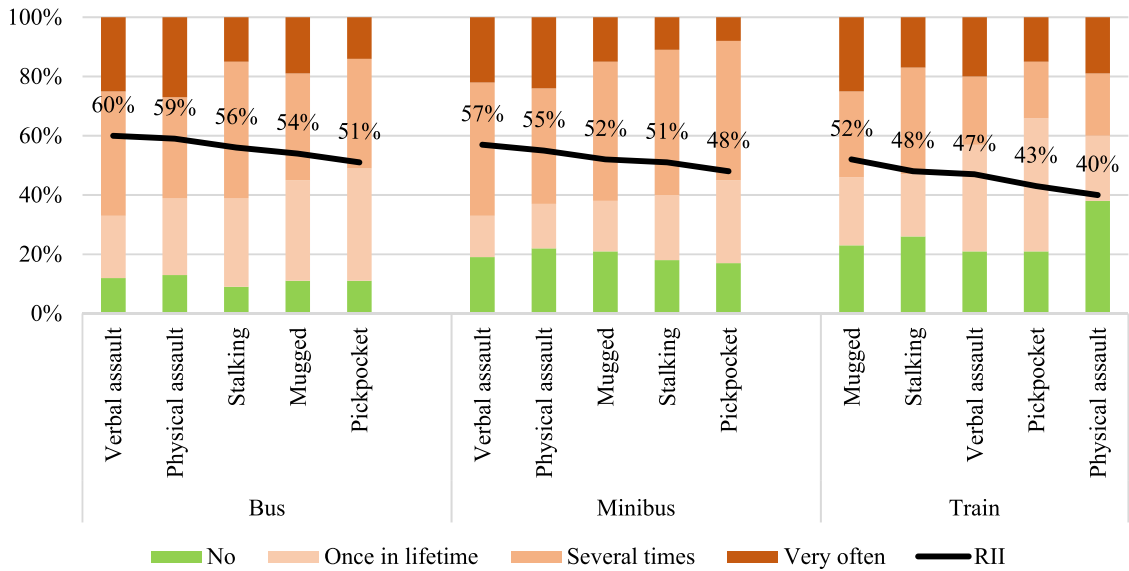


Fig. 2. Participants' frequency experienced violence.

in bus, and 58% in train transport mode. A low women-oriented RII report on minibus compared to bus and train could be due to female restriction or security concerns due to infightings/conflicts between minibus drivers that usually result in severe incidents in South Africa. The participants identified the most women-oriented item in the bus transport as the bus stations (59%) and the least as the toilet facilities (48%). Women's inclusivity is mostly perceived in the vehicle in the minibus station (53%) and the train modes (60%) as illustrated in Fig. 3.

Public transport performance

The overall RII indicates women's evaluation of public transport and the level of satisfaction with public transport systems in South Africa as illustrated in Fig. 4. The RII shows that the women are more satisfied by the overall services provided by the minibus mode (65%) followed by train (61%) and bus (58%).

The reported low level of satisfaction experienced by women using the services provided by bus systems could be due to the operation of old buses that lack comfortability and safety and have not adopted new technologies, and lack of maintenance culture in terms of renovation of the stations and refurbishing and updating old buses operating in South Africa. Similarly, the lower satisfaction experienced by train service commuters compared to minibus commuters could be attributed to poor, unreliable and unsafe services

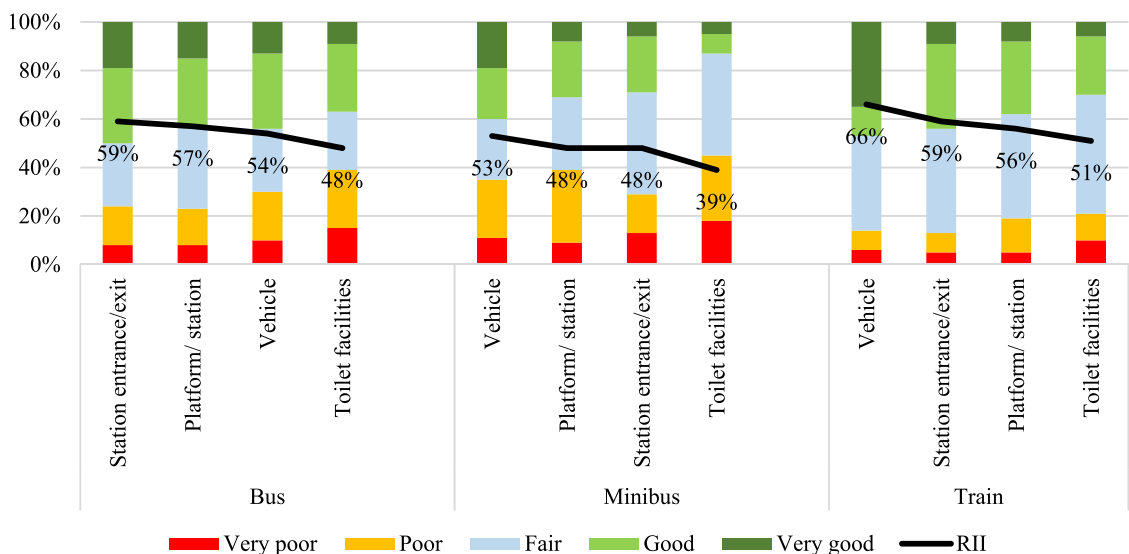


Fig. 3. Female inclusivity of public transport.

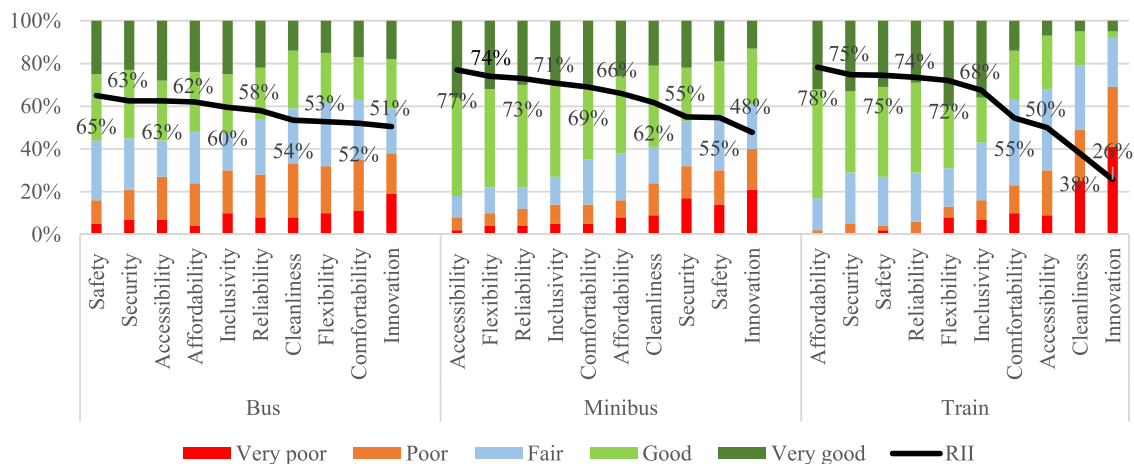


Fig. 4. Participants' evaluation of public transport system.

provided by the train system in South Africa, which is caused by operating old and obsolete fleet and technology and limited routes of trains.

The performance analysis shows that the safety from accidents (65%), personal security (63%), accessibility (63%), and affordability (62%) of the bus are satisfactory. The participants evaluated the accessibility (77%), flexibility (74%) and reliability (73%) performance of the minibus as the top three. While the top performances of the train are affordability (78%), personal security (75%) and safety (75%). Nevertheless, innovation and technology implementation appear challenging in all three transport modes, particularly train (26%). This is possibly due to a lack of a maintenance culture that is swift to embrace innovation and technological advancement, which could be due to fiscal and budgetary constraints.

Causal model

To validate the developed causal model and association between the constructs, all identified influential factors and sub-factors were included in the initial model in SmartPLS. The hypothesized model was tested using collected data.

Analysis of the measurement model

The measured variables were assessed for consistency, reliability and validity using confirmatory factor analysis. The results of the internal consistency, composite reliability, convergent validity tests and discriminant validity are summarised in Table 4.

Reliability in quantitative research indicates that the scores received from the respondents are consistent and stable over time; reliability is often assessed through reliability coefficients [56]. Statistical analysis was used to check the reliability of the data collected from female passengers. The Cronbach's alpha coefficient of each question response and the internal consistency ratio of the overall responses to each questionnaire (train, bus and minibus) were calculated. The values of Cronbach's alpha that are commonly used to determine the internal reliability, consistency, and co-variation among variables related to the measurement of each construct often range from 0 to 1 [58]. The results of Cronbach's Alpha are between 0.7 and 0.95, which indicates a reliable internal consistency between the sub-factors under the same influential factor and that the sub-factors are not highly inter-correlated.

Furthermore, the coefficient rho-A test results between Cronbach's Alpha and Composite Reliability also prove the acceptable internal consistency between the variables of the study's sub-constructs. The composite reliability test results and Average Variance Extracted (AVE) tests are above 0.7 and 0.5, respectively, which prove the reliability and convergent validity between sub-factors and indicate that the developed model's reliability is acceptable. Furthermore, the square root of the AVE value of each measured

Table 4
Consistency, reliability and validity of the constructs and variables.

Construct	Variables	Socio-demographic	Violence	Women-oriented	Transport performance	Transportation Choice
Socio-demographic	5	0.797				
Violence	4	-0.772	0.819			
Women-oriented	4	0.779	-0.800	0.811		
Transport performance	10	0.717	-0.775	0.782	0.714	
Transportation Choice	2	0.788	-0.801	0.797	0.701	0.836
Internal consistency	Cronbach's Alpha	0.776	0.782	0.779	0.735	0.807
	Rho-A	0.791	0.800	0.798	0.762	0.812
Composite reliability		0.803	0.817	0.810	0.835	0.842
Convergent validity		0.635	0.642	0.639	0.562	0.670

influential factor is greater than the correlation coefficient between the sub-factors, as shown in Table 6. This outcome indicates that measures of variables that theoretically should not be highly related to each other are, indeed, not found to be highly correlated to each other.

Following the reliability and validity checks, the fitness-for-purpose of the casual model of transport choice was evaluated. As shown in Fig. 5, the R-squared values for the constructs are above 0.7 which indicate the strength relationship between the developed model and the dependent variable. Moreover, the results from the analysis of the model show that all fit indices of model are above the recommended values ($\chi^2 = 3111.670$; $\chi^2/DF = 1.125$; $p = 0.000$, CFI = 0.734; GFI = 0.717; RMSEA = 0.014).

Finally, the path analysis for the causal model was developed. As illustrated in Fig. 6, all loading factors of variables are greater than 0.8, indicating highly satisfactory relationships of variables in the reflective measurement of constructs and the model. Since all the variables are above the acceptable level, they were used to discuss the importance of each variable for the defined constructs in the model for the purpose of identifying which variables should be focused on the public transportation choice by the women model. Overall, the results of these tests prove that the collected data have high satisfactory validity, reliability, and internal consistency.

Analysis of the structural model

After analysing the measurement model, the research hypotheses were tested using T-Statistics. The resultant P-Values of all hypotheses (paths) tests are less than 0.05, which indicates all research hypotheses and their sub-hypotheses are statistically significant, as presented in Table 5.

Based on the results from the testing of the hypotheses as listed in Table 5, the study deduced that:

- The sociodemographic characteristics of women commuters have a significant positive influence on the choice of women on the mode and time of using public transport, which is aligned with findings of Mhlanga and Mokonyama [26] and Vanderschuren et al. [34].
- The experience of gender violence by women commuters has a significant negative influence on the choice of public transport mode and time by women, aligned with Matthewson and Kalms [51] and Gekoski et al. [17].
- The women-oriented public transport variables have a significant positive influence on the choice of women on the mode and time of using public transport, which is aligned with Kett et al. [52] and Sambo [35].
- The public transport performance experienced by women commuters has a significant positive influence on the choice of women on the mode and time of using public transport, which is aligned with UN-Women (2017), Asian Development Bank [5] and Benoliel et al. [10].

Moreover, the indirect effect testing of the research hypotheses proved that the violence experienced by women and the women-oriented are mediating respectively negatively and positively the influence of transport performance on the public transport choice by women. Therefore, the total effects of transport performance on transport choice are slightly reduced, as illustrated in the final causal

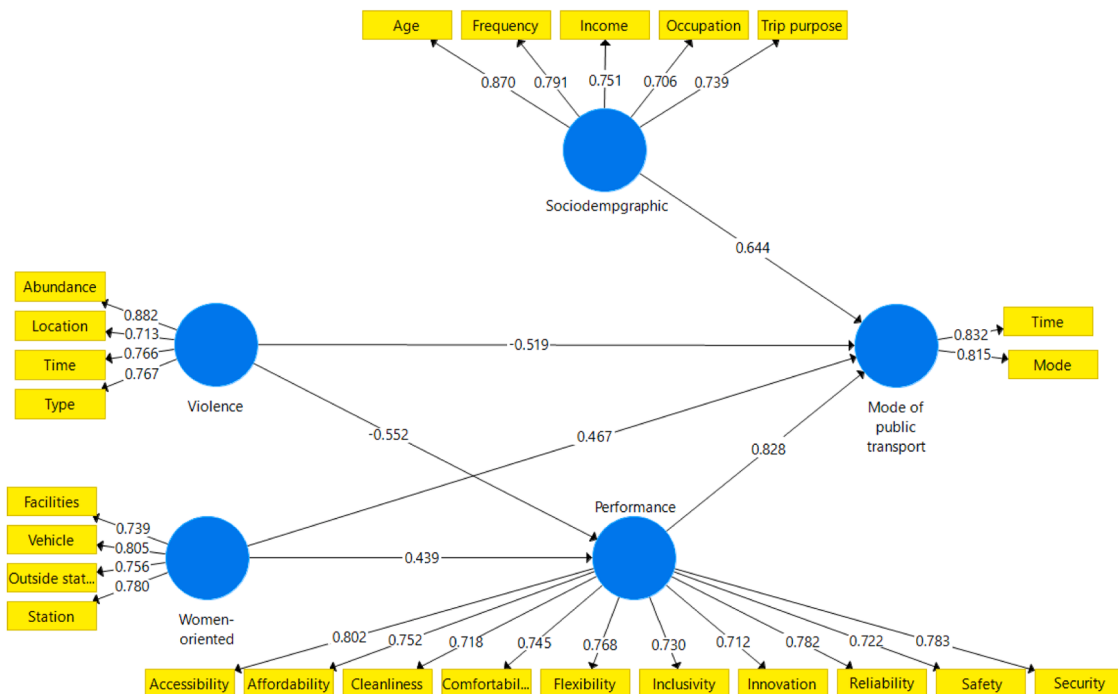


Fig. 5. Path analysis.

Table 5
Hypotheses testing results.

Hypothesis	T Statistic	P Value	Decision
H1: Sociodemographic -> Transport choice	12.327	0.000	Significant
H2: Gender-based violence -> Transport choice	3.130	0.002	Significant
H3: Women-oriented -> Transport choice	5.683	0.000	Significant
H4: Transport performance -> Transport choice	24.792	0.000	Significant
H5: Gender-based violence -> Transport performance -> Transport choice	3.721	0.002	Significant
H6: Women-oriented -> Transport performance -> Transport choice	5.975	0.000	Significant

model in Fig. 6. The research hypotheses tests validated the developed public transport choice by the women model.

Fig. 6 shows the total effect coefficient among constructs. The sociodemographic characteristics of women commuters have a moderate ($0.5 < e = 0.644 < 0.69$) positive effect on the public transport choice. The results of the total effect coefficient also reveal that experienced violence has a moderate ($-0.5 < e = -0.519 < -0.69$) negative influence on the public transport choice. In contrast, women-oriented transport has a low ($0.3 < e = 0.439 < 0.49$) positive influence on the public transport choice by women.

Moreover, As illustrated in Fig. 6, experienced violence and women-oriented are mediating the influence of transport performance on the public transport choice. However, since the negative mediation of experienced violence is larger than that of the women-oriented, the experienced violence slightly reduced the total influence of transport performance on transport choice. Nevertheless, the transport performance factors have a high ($0.7 < e = 0.644 < 0.89$) positive effect on transport choice, and it is the primary influence factor on selecting public transport by women in South Africa.

Finally, the influences of each of the influential sub-factors are estimated using formula 1, and the results are ranked according to their relative importance in Table 6.

$$Influence\ coefficient = \frac{|total\ effect\ of\ factor| \times outer\ weight\ of\ sub - factor}{\sum(|total\ effect\ of\ construct| \times outer\ weight\ of\ variable)} \tag{1}$$

Outer weights are the results of multiple regression of a construct on its set of indicators which assess each indicator’s relative importance, and informative measurement models.

The influence of sub-factors indicates that the security (12.7%), affordability (11.8%), inclusivity (10.9%) and accessibility (10.8%) of public transportation performance and abundance (−10.8%), type (−10.2%) and time (−9.2%) of gender violence are the dominant sub-factors that influence the transportation choice by South African women. On the other hand, the outside station women-oriented (3.7%) and innovation (2.5%) are the two sub-factors that have less influence on the choice of South African women.

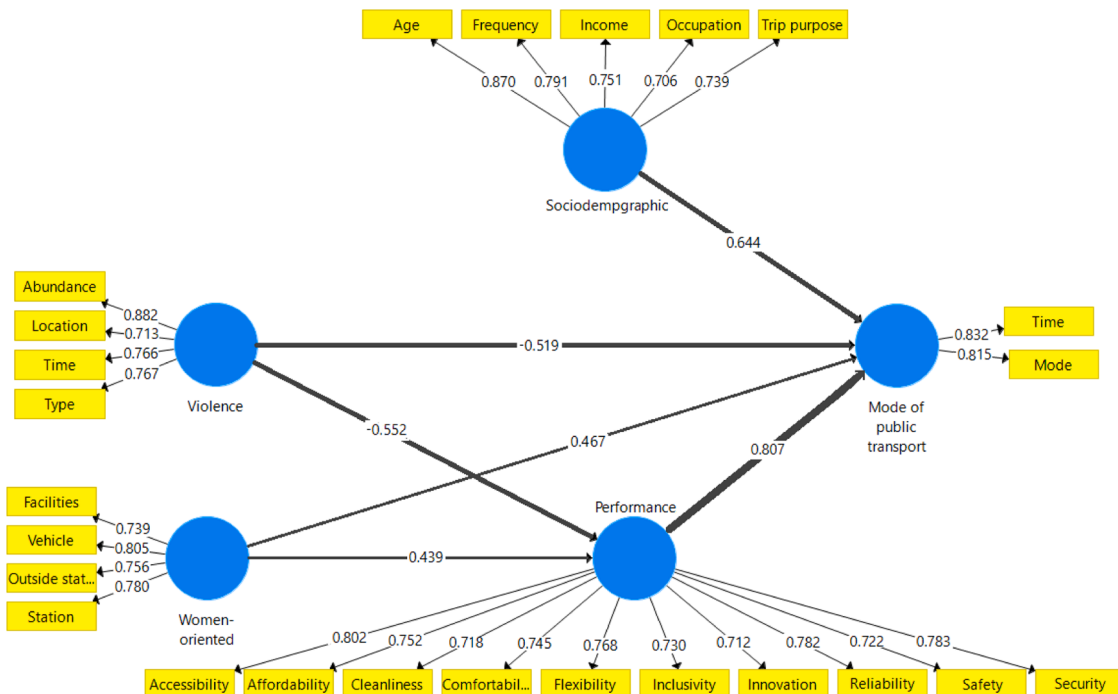


Fig. 6. Total effect of public transport choice model.

Table 6
Influence coefficient of sub-factors.

Construct	Variable	Influence coefficient	Rank
Transport performance	Security	12.7%	1
Transport performance	Affordability	11.8%	2
Transport performance	Inclusivity	10.9%	3
Transport performance	Accessibility	10.8%	4
Violence	Abundance	-10.8%	5
Violence	Type	-10.2%	6
Violence	Time	-9.2%	7
Sociodemographic	Age	9.2%	7
Transport performance	Reliability	7.9%	9
Transport performance	Flexibility	7.1%	10
Transport performance	Safety	7.0%	11
Sociodemographic	Frequency of trip	6.8%	12
Women-oriented	Station	6.7%	13
Women-oriented	Facilities	6.6%	14
Violence	Location	-6.5%	15
Transport performance	Comfortability	6.4%	16
Sociodemographic	Income	6.2%	17
Sociodemographic	Occupation	6.2%	18
Women-oriented	Vehicle	5.5%	19
Sociodemographic	Trip purpose	4.6%	20
Transport performance	Cleanliness	4.2%	21
Women-oriented	Outside station	3.7%	22
Transport performance	Innovation	2.5%	23

Discussion

The study has evaluated the security and inclusivity of South African public transport for women based on collected data from female commuters. Furthermore, the study examined the causality and assessed the influence of sociodemographic characteristics of commuters, experienced violence, women-oriented of transport mode and transport performances on the selection the public transport mode and time by women in South Africa. Consequently, a public transport choice casual model was developed and validated using SEM.

Women in South African public transport

Global experiences indicate that modifying transport infrastructure investments and services with a gender-intuitive approach maximizes transport services and increases infrastructure benefits, yielding direct social, environmental and economic benefits [5,53]. The sociodemographic of women commuter results from this study indicate that most women who utilize public transport are relatively young and are either unemployed or belong to the low-income level. Their economic status in society places them in the lower strata, so the majority only use the bus and train services because of their affordability. Those who can afford the bus are mostly younger, whereas the older prefer the train and minibuses. The general results indicate that most of the women using the bus and train belong to the low-income groups, while the majority of women in the high-income group use minibuses.

Furthermore, the study found that most women use public transport for daily commutes to work, study, and take children to school in South Africa. However, South African women do not prefer public transport for their care trips or visits/leisure trips. The findings from the sociodemographic data align with UN-Women [36] and Sambo's [35] argument on how poverty has been 'feminized' because the current systems have failed to recognize that women make up half the world's population and perform two-thirds of the world's working hours, receive one-tenth of the world's income and own only one-hundredth of the world's property. Therefore, where women's economic situation is directly proportional to their mobility levels, efficient public transportation systems become a relevant tool for empowering and enabling women to access jobs and economic opportunities.

Women constantly face numerous mobility obstacles, even when they represent the largest statistic of public transport users globally. International literature has revealed that women make more trips on average than men [34]. In addition, women embark on care trips such as food, shopping, school and health trips for kids or sick family members more frequently and thus are prone to show trip changing behavior [59]. Although, in this study, the reason for women's trips varies, so too does the mode of transport used; however, the majority women use three modes of public transport to get to their workplace and educational institutions.

Furthermore, affordability is the primary reason women use trains and buses in South Africa [27], and ironically, the train is supposed to be the cheapest. Yet, the overall picture reveals that the minibuses is preferred to other modes, except for safety from accident concerns, since the safety is one of the most important influencing factors on selecting public transport by women as Fu & Juam [38] and Allen & Vanderschuren [59] also proved this finding. However, this is an interesting finding because the general notion is that minibuses are more prone to accidents than other public transport modes in South Africa, proving the lack of public knowledge regarding the safety of different transportation modes in South Africa.

Women's safety, security and wellbeing are hardly considered in transport infrastructure and services policy and planning in South

Africa, which is no different from many other countries in Global South [1]. This is despite the fact that the risks of violence and crime on public transport are greater for women [34]. This often affects women's choices, decisions and willingness to travel, and also deter their economic and financial independence as many scholars have provide these findings across various geographical locations [7,17,59]. This study reveals that the overall gender violence rate is higher in buses as compared with trains and minibuses.

This concurs with the National Household Travel Survey [45] which indicates that security is a primary concern for female travellers. Vanderschuren et al. [34] reported that 80% of South African women are afraid of being harassed in public spaces, and that most household heads consider the public transport journey too risky for females. This has a corresponding effect on their long-term wellbeing. The overwhelming neutral stance by participants could be due to the uncertainties around safety in South Africa, where people are sceptical and unsure of what will happen at any given minute while travelling by public transportation.

Regarding the issue of gender violence, the female respondents show that verbal assault is predominantly experienced in buses and minibuses, while mugging dominates on the train. The findings demonstrate that women have experienced pickpocketing, stalking, mugging, and verbal or physical abuse on the bus, minibus, or train, either once or several times in a lifetime. Carvajal and Alam [6] agree that gender violence must be treated as a development challenge to find a long-term solution to public transportation. Asian Development Bank [5] concurred that strict sex segregation, especially in public spaces, should be the cultural norm in some socio-cultural contexts. As revealed in this study, the possible solutions to improving the security of South African public transport modes are public awareness information and modernizing the public transport by utilizing relevant social and technological innovation.

Inclusivity in public transport planning, policy and implementation is a concern in most societies and communities. This influences the social and cultural acceptance of women's independent travel beyond the home and vicinity of the community and constrains women's mobility and accessibility to socioeconomic opportunities. Despite South Africa being a somewhat more liberal society, it is considered unacceptable for women and girls to travel on crowded public transport alongside male strangers in some contexts. Hence, while considering whether public transport performance satisfied their various needs in this study, all the respondents report on sub-factors of performance and inclusivity of South African public transport modes.

For instance, on the one hand, safety, accessibility, security and affordability of bus performance for women are good, even though the comfortability and flexibility can sometimes be problematic. Similarly, the train is perceived to be a suitable transport mode for women in terms of affordability, security, and safety; however, the cleanliness and accessibility performances of the train are poor. On the other hand, the minibus' performance regarding accessibility, flexibility and reliability are good, while it has a poor performance in safety and security.

Whether these influential sub-factors were related to women's choices or not shows that it is not easy to travel with luggage and a child whilst mixing with other passengers. The study proves that the South African public transport stations and facilities are not designed for females. Therefore, to improve the transport performance and achieve women-oriented public transport, it is necessary to integrate the women's essentials in the design and operation of public transportation systems.

Women's public transport choice

The women's transport choice SEM shows an acceptable validity of the developed model. The total effect of influential factors in the final causal model confirmed the positive influences of sociodemographic (moderate), women-oriented (low), and transport performance (high) and the negative (moderate) effect of gender violence on both the mode of transport and time of travel choice by women in South Africa. Furthermore, the final casual model revealed the mediating effect of gender violence (moderate negative) and women-oriented (low positive) on the influence of transport performance on women's public transport choices.

Moreover, research hypothesis and findings in total effect analysis proved that a woman's transport choice is strongly associated with the rate of gender violence and the level of security of transport mode. This finding implies that reducing the rate of violence against women will significantly enhance South African women's use of public transport. This is not only because of the direct negative influence of gender violence but also the negative mediator impact of gender violence on transport performance. This finding is consistent with those of previous studies by Vanderschuren et al. [34], Matthewson and Kalms [51] and UN-Women [36], who acknowledge that violence against women in public transport significantly affects the level of trust, frequency and time of use public transport by women.

The women-oriented and transport performance influential factors provide the essentials and capability to enhance women's use of public transport by addressing the barriers that limit the mobility of women. The validation of the women's transport choice model attests to the applicability of the model as a mechanism for increasing the frequency of use of public transport by women and for advancing the actualisation of inclusive public transport. Also, it implies that the model can be used to understand and identify the influential variables and challenges negating inclusive public transport. In practice, the model serves as a guideline for the public transport operators to understand the needs and challenges of women commuters and acts as a roadmap for local and national public transport stakeholders and policymakers to achieve safe and inclusive public transport.

The results of the influence coefficient proved that the security, affordability, inclusivity and accessibility of public transportation performance and abundance, type and time of gender violence are the key influential sub-factors on the women's transport mode and time choice as also mentioned by Mhlanga and Mokonyama [26] and Benoliel et al. [10]. Moreover, the lack of utilizing technological innovation is directly connected to several poor performances of public transport in South Africa, such as safety, security, reliability and cleanliness. Therefore, using innovative technologies could eliminate the negative influence of gender violence and address the poor transport performances, as also highlighted with Kett et al. [52].

The current study presents several theoretical and practical implications for academics, practitioners and policymakers. For

instance, the findings of this study provide valuable knowledge on the critical role and effectiveness of inclusivity of public transport for women. Practically, the results of this research contribute to understanding and prioritizing women's needs and addressing the challenges to planning toward revolutionizing the current public transport, in order to achieve inclusive public transport in developing countries such as South Africa.

Conclusions

This study identified the needs and challenges of women in South African public transport by empirically examining the degree of inclusivity, extent of gender violence experienced and satisfaction with performance of three modes of public transportation. An outcome of the study is the establishment of a women's transport choice model which validates the effects of influential factors and their sub-factors on their transport choice. The findings of this study revealed that the level of inclusivity in South African public transport for women is notably low. At the same time, the rate of violence against women in all three modes of public transportation in South Africa is significantly high.

The results of this examination verified that the mode of public transport chosen by women is positively associated with the sociodemographic profile of commuters and women-oriented transport performance and is negatively related to gender violence. The positive associations make it possible to conclude that the use of public transport and choice of transport mode by women is not solely dependent on the sociodemographic characteristics of commuters but is also impacted by the level of inclusivity and performance of each transportation mode. However, the study's findings reveal that some sub-factors, such as the age of commuter, time of travel, abundance, type of violence, accessibility, and security of transport mode, have a greater influence on women's transport choice. Based on these findings, it can be concluded that to address the current challenges of women and enhance their public transport utilization in South Africa, gender violence in public transport must be eliminated, and inclusivity and transport performance must be improved.

Furthermore, the findings of this study showed that the perception of South African women regarding the security and inclusivity of public transportation is integral to women's economic participation. Increasing women's access to and usability of public transport will elevate their overall economic and social growth. Besides the general rights-based equality rationale that is globally propagated, narrowing these gender gaps also has an economic efficiency rationale. Integration in transport sector jobs can benefit women directly and indirectly, in several ways to improve their families and communities. This study found that many women are unsure of their safety and personal security while using the different modes of transport, reflecting the general security concerns around transportation. Furthermore, the study reveals the location and time transport crimes happen, the condition of transport facilities in relation to women, and the possible solutions to address transportation safety challenges.

Theoretically, the current study extends the postulations on the influences of sociodemographic, violence and transport performance on women's use and choice of public transportation. Furthermore, it can be concluded from the findings of this study that appropriate strategic national and local plans are required for designing and developing inclusive and secure public transport by integrating the needs of women in all components of public transportation. The government's strong commitment and political willingness are crucial in improving current gender-oriented ideals' cultural habits and social standards. In conclusion, the study recommends adopting several short-term and long-term remedies to improve the condition and services of public transport for women using new technologies.

Recommendations for future studies

The research provides a systematic basis for future studies to assess the actual effectiveness of influential variables on the women's public transport choice and the performance of inclusive public transport through a multi-case study approach. Hence, this is a complex and multidisciplinary action that requires that all public transport stakeholders should understand the needs and challenges of women, and that the knowledge should be disseminated among them. Therefore, policymakers, designers, and transport operators must ensure that inclusive and secure public transport executives become conversant with necessary changes and ensure that all parties acquire the essential understanding and awareness of adopting the right strategy and methods.

Future studies should also consider measuring the impact of various technological innovations on the inclusivity and security of public transportation. Moreover, future studies could investigate essential policy and implementation strategies that overcome the violence against women and their other challenges. Finally, due to the high similarity of the women's needs and their challenges in public transport in developing countries, as shown in the study, the women's transport choice model could be generalised in similar developing country contexts. This study is focused on three modes of public transport in Gauteng. Hence, it does not fully represent the state of South African transport nor the gender inclusivity of South African public transport.

CRedit authorship contribution statement

Alireza Moghayedi: Conceptualization, Methodology, Formal analysis, Resources, Data curation, Writing – original draft, Visualization, Project administration, Funding acquisition. **Abid Mehmood:** Conceptualization, Validation, Data curation, Writing – original draft. **Emmanuel Matsika:** Conceptualization, Investigation, Resources, Project administration, Funding acquisition. **Marianne Vanderschuren:** Methodology, Validation. **Karen Le Jeune:** Validation, Visualization, Writing – original draft. **Christiana Okobi Ekpo:** Writing – review & editing. **Ifunanya Chukwueke:** Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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