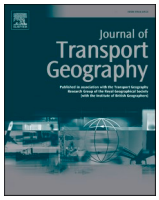
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Women's perceived safety in public transport: Insights from the Middle East☆

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ABSTRACT

This study examines the physical, social, and temporal dimensions that affect Iranian women's perceptions of safety during travel on public transit. We employ both primary and secondary data: a survey of 680 female users of the Shiraz subway and GIS shapefiles. Our Partial Least Squares Structural Equation Modelling (PLS-SEM) explains 34.4 % of the variance in perceived safety. We find that constructs such as access, demographics, design, and surveillance have a direct effect on perceived safety, whereas the effect of timing is only indirect. The effect of surveillance measures, such as CCTV cameras, police officers, and lighting, is the most influential, explaining 43 % of the variance in perceived safety. This suggests that, in the case of Shiraz, enhancing these measures may be a particularly effective strategy to boost safety perceptions among female passengers. However, we acknowledge that excessive surveillance can backfire and may also be objectionable on ethical grounds. Beyond infrastructure measures, the real challenge is to cultivate a feeling of collective responsibility for women's and girls' safety and empower female riders to confront and report perpetrators.

1. Introduction

The rates of gender-based violence on public transport – theft, assault, sexual harassment – are alarming. Up to 87 % of women in France have experienced sexual harassment in public transport (ECE, 2016); in Japan, the rate is 75 % (AMI, 2019). In less developed regions, the figures are similar or higher: up to 90 % in Pakistan (UN Women, 2018) and up to 84 % in Colombia (Jaitman, 2020; Quinones, 2020). Needless to say, fear of victimisation leads many women to avoid public transport. Where they are transit-dependent, women become stressed, anxious, and hypervigilant during travel or are forced to divert their movements to safer but less convenient times and routes. This situation is lamentable first and foremost from a social justice and ethical perspective. But reduced public transport use is also problematic in terms of pollution, congestion, and living expenses (Saif et al., 2019; Friman et al., 2020).

In Iran, studies of gender-based violence on public transport are scarce (see Heidari, 2018; Khakzand et al., 2015). Yet Iran – as the rest of the Middle East – is an interesting case study because its context is radically different from Latin America and South/Southeast Asia where most research on this topic is concentrated. Iranian women's access to public spaces – including public transport - was historically restricted due to religious norms and cultural practices (Ratthinan and Selamat, 2019; Almahmood et al., 2018; Faxon et al., 2015). Regions where Islam prevails tend to also be traditional and masculine, with rigidly defined gender roles. In such environments, women often feel unsafe or unwelcome due to societal expectations and norms that prioritize male dominance and control over female behaviour.

However, Islam can also offer a form of protection, rooted in male guardianship, provided that men follow its principles closely and as originally intended. The Koran, for instance, explicitly prohibits coveting other men's wives, which can serve as a deterrent against sexual harassment. Both men and women are instructed to maintain modesty and moral conduct. Men are admonished to lower their gaze and guard their chastity, just as women are advised to dress modestly. Also, men

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are given the responsibility to protect and provide for women and ensure women's security. Additionally, with Iran being an honour-based society, men may avoid harassing and harming women out of fear of retribution from the woman's male relatives, such as her husband, brother, or father.

This creates a paradoxical safeguard from gender-based violence, not based on a woman's inherent dignity, worth, or autonomy but on her being regarded as another man's property. In this context, the man's honour is tied to the behaviour of the woman under his guardianship. This reinforces the idea that women's safety is secondary to the preservation of male honour, and that a woman's value is largely determined by her relationship to a man, rather than her own rights as an individual. Thus, while the system may reduce certain forms of gender-based violence, it does so by reinforcing gender inequality and perpetuating a view of women as subordinate to male authority. The protection offered is conditional, dependent on adherence to Iran's gendered structures.

Now, as Iranian women's educational attainment and workforce presence have increased, they have become more mobile and some of the old restrictions to their free movement are being lifted. The country is in a state of socio-political transition, with many women defying compulsory hijab laws – which, according to the United Nations (OHCHR, 2023) could amount to "gender apartheid". However, social mores are slow to change, and reports by Amnesty International (2023) still highlight grave concerns related to women's rights in Iran, with ethnic minorities being more severely affected (OHCHR, 2024).

In the transport arena, not all men appreciate having to share with women certain spaces that were formerly predominantly male. Others take advantage of women's perceived vulnerability and docility to harass and harm them, thereby forcing them back indoors (Khalili and Fallah, 2018; Lak et al., 2020). Restrictions on driving and cycling have not eased despite much advocacy and acrimony. While there are no restrictions on subway use, women cannot drive independently or ride bicycles or motorcycles without facing some kind of judgment or stigmatization. Consequently, a "fear of public space" (Das, 2017:270) persist among Iranian women (Asl and Azadeh, 2017). This is compounded by negative media portrayals of impoverished areas as criminal hubs (Rajabi, 2022).

This quantitative study delves deeper into the physical, social, and temporal dimensions that affect Iranian women's perceptions of safety during travel. We rely on both primary and secondary data: a survey of 680 female users of the Shiraz subway and GIS shapefiles of subway station areas provided by the Statistical Centre of Iran and the City of Shiraz. The local municipality and police lack a reliable database recording gender-based offences in the subway system, which makes this study all the more necessary.

While grounded in a specific case, the contribution of this study extends well beyond it. We propose a comprehensive framework that links perceived safety to multi-dimensional constructs – including access, design, surveillance, and timing - alongside demographic variables. Although research on gender-based violence in public transport is expanding globally (Tiznado-Aitken et al., 2024; Ison et al., 2023; Infante-Vargas and Boyer, 2021; Mallawaarachchi, 2024; Lubitow et al., 2020; Useche et al., 2024; Quiñones, 2020; Madan and Nalla, 2016; Ison et al., 2024; Hoor-Ul-Ain, 2020; Graglia, 2016; Sushmitha et al., 2024; Cowan and Liu, 2024), it remains theoretically fragmented. Few, if any, studies have integrated the full range of contributing factors into a unified framework. This article takes an initial step toward filling that gap. We describe the Shiraz context and the methodology in some detail after setting forth the conceptual framework for this study below.

2. Conceptualisation

To measure women's safety perceptions in the Shiraz subway system, we have adapted a conceptual framework developed by Yossa et al. (2023) to assess the overall performance of rail transit systems in Asia from the perspective of women. Our adapted framework focuses exclusively on aspects related to women's safety. It has five constructs, in addition to *perceived safety*: *access*, *demographics*, *design*, *surveillance*, and *timing* (Table 1). The constructs and the respective metrics are discussed below. We maintain that, for women to feel comfortable while traveling on a subway (or other public transport mode), all aspects of the experience should be perceived as safe.

3. Perceived safety

Public perceptions of safety reflect individual interpretations of risk, which are not static but change depending on the situation, context, and past experiences. Societal narratives, media portrayals of crime and violence, and features of the built environment also influence safety perceptions. Regardless of objectively measured crime rates, individuals may exhibit varying responses, appearing fragile or self-confident, calm or agitated, for example. Fear, an emotional response to perceived threats, can serve as a protective mechanism but can also create unnecessary tension and, for women, limit their independence. Conversely, some women may exhibit an optimistic bias, downplaying the risks to their personal safety. This study examines perceived safety in relation to three aspects of the built environment:

Subway cars: Generally, women feel less safe in crowded vehicles (Chowdhury et al., 2023) because they are aware that harassment is more likely to occur when people are standing rather than seating (Tirachini et al., 2013).

Station interior (gates / corridors / platforms): In some settings, crowded stations and platforms are the most hazardous for women (Kash, 2019). Lack of station amenities such as benches makes women feel less safe. The relationship between reported and actual wait time is non-linear and changes depending on station amenities (Fan et al., 2016).

Station exterior (400-m radius around station): In some settings, most crimes against female passengers take place on the way to a station (Sham et al., 2013). If the area outside a station is perceived to be safe, women are more likely to feel safe in the station building itself (Verma et al., 2020; Cozens and Van der Linde, 2015).

3.1. Access

First mile/last mile: Shorter trips to reach a public transport station reduce perceived risk (Shi et al., 2019) because there is less exposure to

Table 1
Conceptual framework.

Construct	Metric
Perceived safety	Subway cars
	Station interior (gates / corridors / platforms)
	Station exterior (400 m radius around station)
Access	First mile / last mile
	Active façades
Demographics	Age
	Education / income
	Employment
	Car ownership
Design	Station area
	Car parking
Surveillance	Personnel and equipment
	Cleanliness and maintenance
	Lighting
	Darkness
Timing	Rush hour / off-peak travel
	Reliability / punctuality

Source: Table by authors, adapted from Yossa et al. (2023). A note on positionality before proceeding: The authors' team is composed of urban and transport planners, including both men and women. Some team members reside in Iran, while others live abroad. We believe has enhanced the cultural sensitivity and legitimacy of our approach.

perceived danger.

Active façades: Women feel safer walking along active building façades, such as shop or restaurant windows and doors (Bennetts et al., 2017). In spaces devoid of people, there is no one around to help if needed (Hidayati et al., 2020).

3.2. Demographics

Age: Research shows that younger women are more often the target of harassment (Yavuz and Welch, 2010) because they are perceived as more attractive and docile.

Education / income: Wealthier and better educated women (i.e., those with higher social status) perceive travel as being safer (Verma et al., 2020) because they feel more in control of their lives, know where to ask for help, and feel entitled to help (Ait Bihi Ouali et al., 2020).

Employment: Where more women work, urban environments are perceived as safer (Khameneh and Ebrahimpour, 2014). The presence of women in public spaces and public transport sends a message that a space is safe (Oğuz, 2020; Shi et al., 2019; Jaitman, 2020).

Car ownership: Women who own cars are less likely to use public transport (Dobbs, 2005) in order to avoiding feelings of anxiety and discomfort caused by traveling with strangers (Currie et al., 2013).

3.3. Design

Station area: Area safety perceptions are affected by the quality of buildings and the length and interconnectivity of urban blocks (Currie et al., 2013). Short and interconnected blocks offer more possibility of escape in case of danger (Cozens, 2013) whereas well-maintained spaces imply more people and surveillance (Cozens, 2013).

Car parking: Women tend to feel less safe in parking lots (Stark and Meschik, 2018; Rajabi, 2022; Cozens, 2013) because these block sight lines and perpetrators can hide behind parked cars (Gargiulo et al., 2020). Also, lighting is sometimes poor in parking lots.

3.4. Surveillance

Personnel and equipment: Surveillance cameras have been shown to objectively reduce crime rates (Priks, 2015). In addition, a visible presence of security cameras (CTVs) and police or station security personnel assuages women's safety concerns, at least in some contexts (Yavuz and Welch, 2010), as women are led to believe that rules will be enforced / misdemeanors will be punished.

Cleanliness and maintenance: Women feel safer in public transport vehicles and station spaces that are clean and well-maintained (Meghna et al., 2020; Jesper and Nielsen, 2021; Camille et al., 2017) because these imply more eyes on the street (Cozens, 2013).

Lighting: Women feel safer in spaces that are well lit (but where lighting is not too harsh (Koskela and Pain, 2000; Christine and Linda, 2014). Visibility adds to safety perceptions whereas darks spaces appear scary and unprotected (Yang et al., 2022; Gill and Nicole, 2021).

3.5. Timing

Darkness: Daily commuters feel less safe in the dark, both in the morning (Chowdhury and Van Wee, 2020) or in the evening (Kebede, 2020). This is justified: crimes are objectively more likely to occur in the dark, and women are subjected to more severe harassment late at night (Gekoski et al., 2017; Ceccato, 2017).

Rush hour vs. *off-peak travel:* Women feel less safe using public transport during rush hours when stations and vehicles are crowded (Gekoski et al., 2017) and the chance of physical contact increases (Ceccato and Paz, 2017). Travel spaces feel safer when there are people around but no there is no overcrowding (Vanier and d'Arbois de Jubainville, 2017), such as during weekends or holidays.

Reliability / punctuality: Women feel less safe when information about train arrival / train departure / duration of trip is unavailable at stations and/or aboard vehicles (Sham et al., 2013). Waiting times at public transport stops and stations appear longer when spaces are perceived as unsafe (Fan et al., 2016).

Based on this framework, we hypothesise that some constructs such as surveillance, access, design, and demographics have a direct effect on perceived safety, whereas timing has both direct and indirect effects on perceived safety (Fig. 1). The context of the study and the rest of the methodology are discussed below.

4. Methodology

4.1. Study context

Shiraz is the fifth largest city in Iran and the most populous in the southern region. A linear city bordered by mountains to the west and north, it spans 40 km in length and 15–30 km in width. In the past few decades, Shiraz has become a significant destination for rural-urban migration, resulting in a substantial population growth. Meanwhile, a surge in private car ownership and use has exacerbated intra-city traffic congestion (Soltani and Askari, 2014; Soltani, 2017). In addition to residents, much traffic is also generated by millions of tourists (Panahi et al., 2022; Soltani et al., 2018). While the city offers a variety of natural and historical attractions, its tissue is also characterised by limited permeability, vast urban blocks, numerous dead-end streets, and a many physically deteriorated or abandoned buildings. Open spaces are frequently used for car parking.

Shiraz is one of Iran's few cities with a subway system (Fig. 2). While only one line (Line 1) is fully operational, a segment of Line 2 has recently opened on a part-time basis. Line 3 is under construction whereas Lines 4, 5, and 6 are still in the planning stages. Line 1 is 24.5 km long and runs from the southeast to the northwest, along the densest areas of the city. It has 20 stations which are surrounded by a mix of land uses and mostly with irregular grid street networks (Fig. 3). Despite some shortcomings, the subway is generally regarded as an expedient way to commute, outperforming most other modes (Panahi et al., 2022). However, anecdotal reports exist of women feeling unsafe and uncomfortable on the subway (and other public transport modes). Those reports prompted this research, which seeks to assess safety issues more systematically.

4.2. Data description

To conduct both reliable and responsible research with women and girls in Iran, we drew on international studies that adhere to ethical guidelines and cultural sensitivities. This study employed both primary and secondary data, which were combined to measure the constructs set forth earlier in the conceptual framework. The primary data consisted of a survey of female users of the Shiraz subway. Our methodology emphasized informed consent, safety, and confidentiality to ensure that the research was both respectful and relevant. We adapted a framework for gender mainstreaming in public transport, considering Iran's legal and political context (Abdi and Soltani, 2022).

The survey questionnaire was designed to measure the *perceived safety*, *access*, *demographics*, *surveillance*, and *timing* constructs, which are well-established in theory. About 20 questions were included, with most items measured on a five-point Likert scale. Before administering the survey widely, we pre-tested the questionnaire on a group of 28 passengers. Initial dimensionality was explored using EFA, which confirmed the proposed factor structure with an acceptable Kaiser-Meyer-Olkin value (KMO > 0.70) and a statistically significant Bartlett's Test of Sphericity ($p < 0.001$). A Cronbach's Alpha value of 0.76 was considered as adequate. The questionnaire was peer reviewed for consistency and robustness by four transport planning academics. Construct validity was confirmed through CFA, which yielded good model fit indices (CFI > 0.90, RMSEA <0.08).

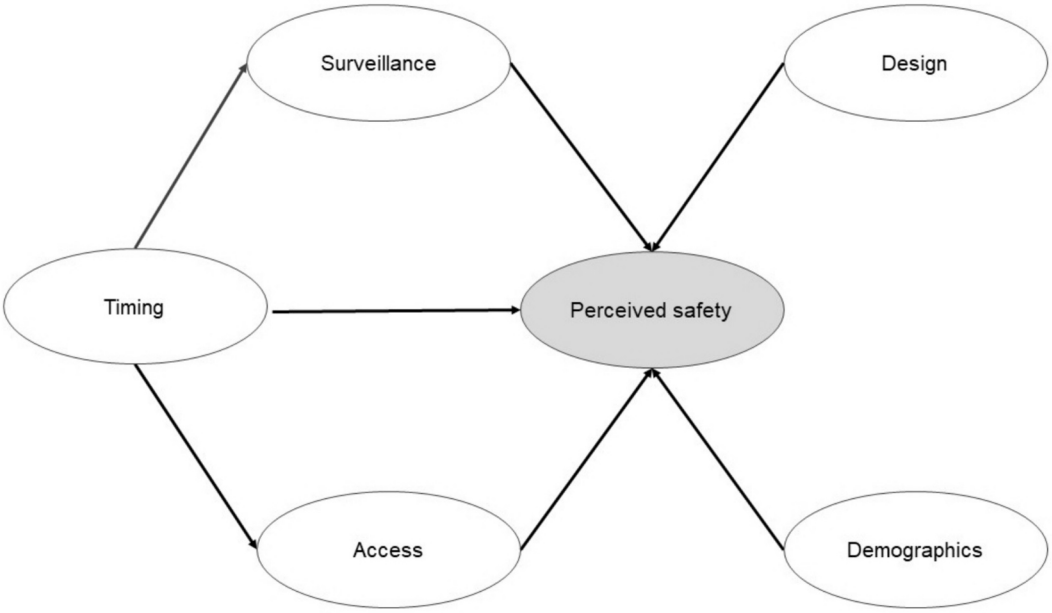


Fig. 1. Conceptual diagram. Image by authors.



Fig. 2. Interiors of the Shiraz subway stations and vehicles. Photos by authors.

Approximately 120,000 people use the Shiraz subway daily, and nearly half of users are women. The minimum sample size for this population is 622 (confidence level 95 %, margin of error 2 %) (Australian Bureau of Statistics, 2022). The surveys were conducted in all twenty stations of Line 1 during the months of October and November 2023. This period was chosen because it coincides with the high school and university teaching semesters. A total of 2000 hardcopy forms were handed out inside the stations, and a Survey Monkey link was posted throughout. The forms were in Farsi, but the results were translated into English for analysis. In total, 714 completed forms were received, for a response rate of 34 %. Upon checking, 34 forms were inaccurate or incomplete and therefore were removed. The final sample consisted of 680 surveys, which were analysed further.

Some basic characteristics of this sample are shown in Table 2. As seen, the Shiraz subway serves a wide range of demographics. However, younger women, particularly students and working adults with flexible schedules, are overrepresented in the survey. This is obviously because these women are more likely to commute. Also, many older people are known to avoid the subway because of its design (e.g., there are no active elevators and the corridors are excessively long). As expected, higher income women are underrepresented in the survey. Respondents are well-educated, with more than half having completed at least some university studies. Importantly, more than half of the respondents live in car-owning households, yet they chose to ride the subway.

The secondary data for this study included spatial data extracted from GIS shapefiles provided by the Statistical Centre of Iran (SCI). We obtained information on current land uses, road network typologies and intersections, population and employment, and public transit features such as bus stops locations, bus routes, and underground subway stations. On-street parking data were also obtained from the City of Shiraz database. We extracted spatial data for each station range (defined as the area within 400 m of the station) to measure the *access* and *design* constructs.[1] The primary and secondary data were combined based on

[1] We did not collect data on crime levels in the station range but note that this factor is known to impact women's safety perceptions (Ceccato and Paz, 2017).

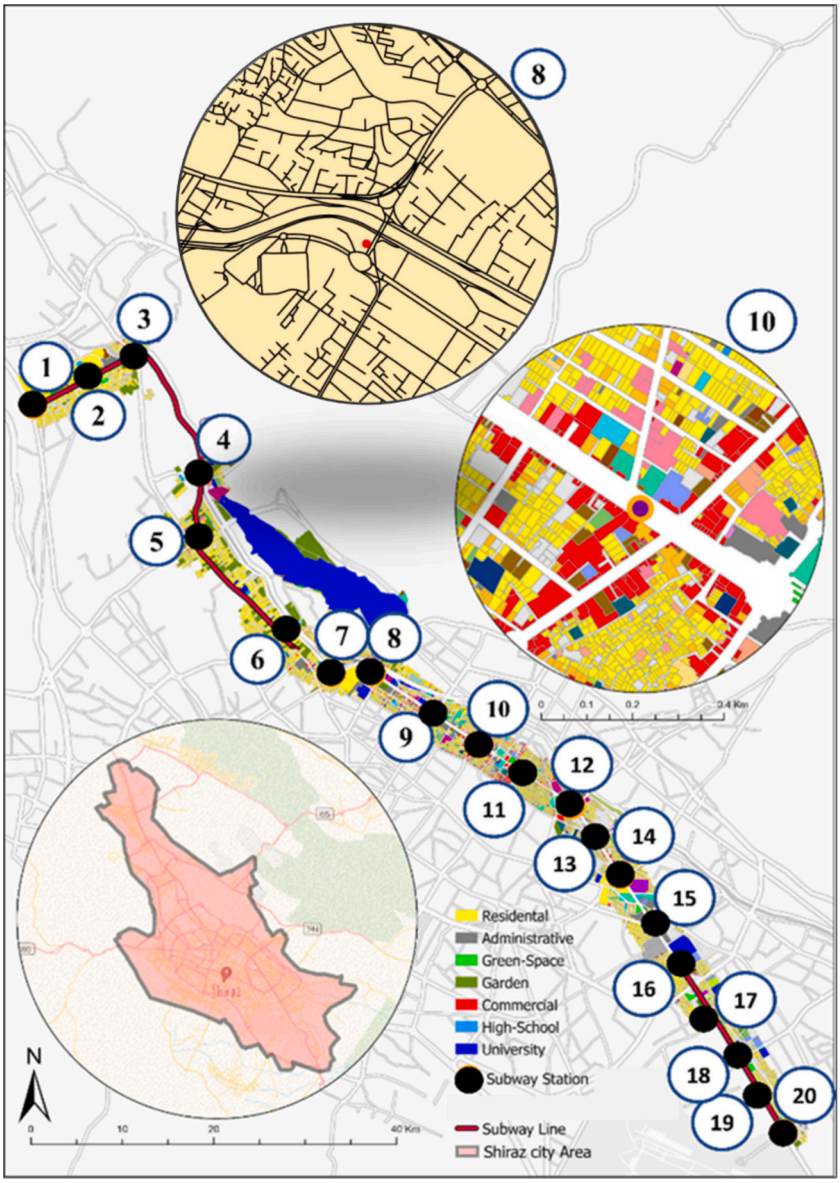


Fig. 3. Shiraz subway Line 1. Land-use activities and street network patterns around two stations (8 and 10). Map by authors.

individual IDs: each female passenger was assigned a unique record to which we attached survey data and built environment data.

The main descriptive statistics of our data (mean, maximum, minimum, and standard deviation for each item) are presented in Table 3. The table combines primary and secondary data. As seen, the level of *perceived safety* varies by location. But generally, women feel safer within train compartments than in station interiors and exteriors. Possibly, they regard compartments as a more controlled environment, especially is CCTV cameras are installed. Regarding the other constructs: on average, *access* is perceived as moderately adequate but there is a degree of variability in perceptions. The urban *design* quality of station areas varies considerably, with some stations being surrounded by small blocks and active street fronts and others set among rundown buildings, parking lots, and other empty spaces. Both types of *surveillance* measures improve the perception of safety, but, interestingly, CCTV cameras are more trusted than security officers (possibly because most officers are men). Stations that are cleaner and well-lit were also perceived as safer. Regarding *timing*, respondents tend to feel less safe late at night and if they have to wait for a while for a train to arrive. The *demographic* characteristics of the sample were described earlier (see Table 2).

4.3. Data modelling

We employ Partial Least Squares Structural Equation Modelling (PLS-SEM) to examine causal relationships between the constructs. PLS-SEM is widely used in behavioural research, including transport behaviour, because, unlike regression analysis, it accounts for both the direct and the indirect effects of constructs on each other, resulting in a stronger explanatory power (Richter et al., 2016; Lee et al., 2011). This technique is particularly suitable for research endeavours like ours that seek to expand upon established ideas (Hair et al., 2019). PLS-SEM can identify new relationships and paths that have not been previously considered in the literature. This tool well handles complex models with multiple variables and smaller samples. This feature is particularly advantageous for research focused on specific groups, such as women, which restricts the sample. The analysis was performed using SmartPLS 4.1.0.3, professional edition.

The model's predictive power is evaluated using two metrics: R^2 and Q^2. R^2 is the coefficient of determination, which quantifies how much of the variation of a dependent variable is explained by the independent variables. It represents the predicted accuracy of the model when tested

Table 2
Survey sample characteristics.

Variable	Category	No.	%
Age*	18-20	49	7.2
	20–30	206	30.3
	30–40	173	25.4
	40–50	121	17.8
	50–60	56	8.2
	61+	30	4.4
	N/A	45	6.62
Occupation	Student	182	26.8
	Working	288	42.4
	Not working	195	28.7
	N/A	15	2.21
Employment	Full time	103	15.2
	Part time	371	54.6
	N/A	11	1.6
Days worked	1 day/week	45	6.6
	2–3 days/week	80	11.8
	4–5 days/week	205	30.2
	6–7 days/week	143	21.0
	Not working	186	27.4
	N/A	21	3.1
Education	High school (up to)	235	34.6
	Some university	84	12.4
	Undergraduate	197	29.0
	Graduate	136	20.0
	N/A	28	4.1
Income	Low income	246	36.3
	Middle income	292	43.0
	High income	45	6.7
	N/A	97	14.3
Car ownership	0 cars	84	12.4
	1 car	371	54.6
	2 cars	145	21.3
	3+ cars	36	5.3
	N/A	44	6.5

* This variable was ultimately excluded from the model because it was not statistically significant.

on the same data it was trained on. The out-of-sample predictive power, also known as predictive relevance, is assessed by the cross-validated redundancy or Q^2 (Ringle et al., 2020). Q^2 is a function of the Sum of Squared Originals (SSO) and the Sum of Squared Errors (SSE). SSO is the sum of squares of observations for each variable while SSE is the sum of the squared differences between the actual values of the dependent variable and the values predicted by the model. Two other metrics which assess the adequacy of the model are the Standardized Root Mean Square Residual (SRMR) and the Normed Fit Index (NFI). SRMR focuses on absolute fit, i.e., is indicates how well our model accounts for the observed data. NFI emphasizes relative fit, comparing our model against a simpler, less constrained model (a baseline model, usually a null model).

All these metrics are shown in Table 4. Our model accounts for 34.4 % of the variability in *perceived safety*, 15.2 % of the variability in *access*, and 27.6 % of the variability in *surveillance*. The Q^2 values are within a moderate range and are considered as acceptable (Hair et al., 2011; Ringle et al., 2020). The SRMR and NFI values are also within the recommended ranges (Hair et al., 2017; Hu and Bentler, 1998). Overall, our model performs satisfactorily. (See Table 4.)

PLS-SEM measures three types of effects: direct, indirect, and total. Indirect effects can be either total (sum of all indirect paths between two constructs) or specific (individual paths). The total effects include all direct and indirect effects. As noted earlier, in our study *surveillance*, *access*, *design*, and *demographics* have a direct effect on *perceived safety*, whereas *timing* has both direct and indirect effects on *perceived safety* (refer to Fig. 1).

The literature recommends a two-stage method for PLS-SEM, including (1) measurement (outer) model evaluation and (2) structural (inner) model evaluation (Hair et al., 2017). The outer models assess the extent to which the observable items accurately represent the underlying constructs, whereas the inner model evaluates the strength of the relationships between the constructs (Russo and Stol, 2021a, 2021b). To ensure model validity, we performed the following tests, with satisfactory results:

1. Inner model. Four criteria must be met (Ringle et al., 2020): (1) the internal consistency of constructs, which is measured using Cronbach's Alpha (CA), the Composite Reliability (CR), and rho_A; (2) the convergent validity, which is assessed through Average Variance Extracted (AVE); and (3) the discriminant validity, which is determined by the Fornell-Larcker Criterion and Heterotrait-Monotrait Ratio; and (4) the collinearity among constructs, which is evaluated via the Variance Inflation Factor (VIF) (see Appendices 1, 2, and 3).
2. Outer model. Two key issues are (1) collinearity among indicators which are evaluated through Variance Inflation Factor (VIF), and (2) indicator reliability, which is evaluated through Factor Loading (FL) and t-statistics (see Appendices 1 and 4).

4.4. Research limitations

The primary limitation of this study is the nature of our sample, which skews toward younger, educated, and employed women, thereby underrepresenting older, lower-income, and non-working women. Consequently, the findings cannot be generalised to all female subway users in Shiraz. Future research should employ stratified sampling to capture the diverse experiences of women across all age and socio-economic groups.

5. Results

The modelling results (direct effects, indirect effects, and total effects) are presented in Table 5, and the statistically significant total effects on *perceived safety* are shown in Fig. 4. The findings are discussed below. As we shall see, they are generally aligned with the literature. While most of the hypothesised effects are statistically significant, the total effects are relatively weak.

Table 5 shows that *access* has a statistically significant negative direct effect on perceived safety, with a β coefficient of −0.128. This suggests that factors such as longer distances to subway stations (from the trip origin and/or destination) and first/last km trips along empty lots and passive street frontages make women feel less safe.

The *demographics* construct also has a statistically significant negative and small direct effect on perceived safety ($\beta = -0.059$). This means that, in combination, factors such as household income, education, car ownership, and employment do affect safety perceptions of female passengers but not in a major way. Overall, women with a higher social status (derived from their education, income, and occupation) feel safer using the subway. This is as expected (Verma et al., 2020; Ait Bihi Ouali et al., 2020). However, age is not statistically significant in the case of Shiraz - which contradicts the findings of similar studies set outside Iran (Moreira and Ceccato, 2020; Kacharo et al., 2022). It may be that here, all women, not only younger ones, feel vulnerable while using the subway. But the finding may also be due to the sample, which was skewed toward younger women.

Similarly, *design* has a statistically significant negative direct effect on perceived safety ($\beta = -0.162$). This suggests that certain design elements such as on-street parking, rundown buildings, dead-end streets, and large blocks may inadvertently decrease the perception of safety among female passengers. While the effect of design is small in this study, existing research similarly points to the quality of buildings, the presence of large parking lots, and the length and interconnectivity of urban blocks as factors that affect women's safety perceptions (Currie et al., 2013; Cozens, 2013; Stark and Meschik, 2018; Rajabi, 2022).

Surveillance has a statistically significant and positive direct effect on perceived safety ($\beta = 0.430$). This means that the presence of security

Table 3
Descriptive statistics, all items (surveys and other data).

Construct / item	Survey question / other data	SD	Min	Max	Mean	Source
Perceived safety						
Safety 1	How safe you feel inside subway vehicles?	0.782	5	1	4.387	Survey
Safety 2	How safe you feel safe at entrance gates / exit corridors of station?	1.228	5	1	3.584	Survey
Safety 3	How safe you feel safe in the outer areas of the station?	1.137	5	1	3.703	Survey
Safety 4	How safe you feel inside the station and on the platforms?	0.939	5	1	3.887	Survey
Access						
Access 1	Is the subway station within walking distance of your trip origin?	1.273	5	1	2.971	Survey
Access 2	Is the subway station within walking distance of your trip destination?	1.338	5	1	3.345	Survey
Access 3	Total area of empty lots or vacant buildings (m^2)	17,059	152,156	22,429	88,090	GISCS
Access 4	Total area of lots with blind façades (m^2)	122,972	171,978	46,220	102,206	GISCS
Demographics						
Demographics 1	What's your income range (SCI-based)?	2.41	10	1	3.981	Survey
Demographics 2	How many vehicles does your household own?	0.621	8	0	1.5	Survey
Demographics 3	How many days a week do you work?	0.481	7	0	3.365	Survey
Demographics 4	What is your education level?	0.641	3	1	1.232	Survey
Design						
Design 1	Total area of on-street parking spaces (m^2)	169	863	82	356	GISCS
Design 2	Total built area with rundown buildings (m^2)	8803	35,302	3051	17,261	GISCS
Design 3	Total number of dead ends	15.6	63.4	11.3	26.4	GISCS
Design 4	Total area of urban blocks larger than 2000 m^2 (m^2)	37,361	202,463	19,772	127,982	GISCS
Surveillance						
Surveillance 1	How safe you feel inside subway cars when there are CCTV cameras?	1.438	5	1	3.487	Survey
Surveillance 2	How safe you feel inside the station when there are CCTV cameras?	1.169	5	1	4.123	Survey
Surveillance 3	How safe you feel when security officers are present?	1.093	5	1	3.874	Survey
Surveillance 4	How safe you feel when stations are clean and well maintained?	1.053	5	1	4.19	Survey
Surveillance 5	How safe you feel when the station areas are well lit?	1.242	5	1	4.061	Survey
Timing						
Timing 1	How unsafe you feel in the late hours of the evening?	1.317	5	1	4.21	Survey
Timing 2	How unsafe you feel during rush hours?	0.912	5	1	2.223	Survey
Timing 3	How unsafe you feel when train arrives late or you arrive late?	1.351	5	1	3.787	Survey
Timing 4	How unsafe you feel when you ride the subway on holidays and weekends?	0.542	5	1	3.426	Survey
Timing 5	How unsafe you feel in the early hours of the day?	0.784	5	1	1.732	Survey

Notes: SCI: Statistical Centre of Iran; GISCS: GIS maps of City of Shiraz.

Table 4
Predictive power and model fit.

Construct	R^2	SSO	SSE	Q^2 (1-SSE/SSO)	*Predictive relevance*
Perceived safety	0.344	1240	1071.817	0.136	meaningful and moderate
Access	0.152	1240	1204.864	0.028	meaningful and small
Surveillance	0.276	1550	1399.691	0.097	meaningful and moderate

Standardized Root Mean Square Residual (SRMR) = 0.029
Normed Fit Index (NFI) = 0.871

cameras and personnel, as well as adequate maintenance and lighting within stations make women feel safer. As shown in Fig. 4, surveillance has the highest effect on perceived safety, though its impact depends, to a certain extent, on timing. We devote the next section to the complex interpretation of this finding.

Timing has a statistically significant but indirect effect on perceived safety through access (β = 0.226) and surveillance (β = 0.050). This indirect effect is larger than most direct effects of other constructs. The dotted line in Fig. 4 shows that the direct effect is not statistically significant. This implies that women may perceive the same station as more or less accessible and/or monitored depending on the time of travel. For example, the journey to and from a station in the dark is likely to be perceived as scarier. As a result, stations that are physically close may appear as less accessible and therefore less safe. Additionally, stations themselves may appear deserted off-peak or at night. The absence of other passengers (a form of informal surveillance) can heighten feelings of vulnerability, regardless of the presence of CCTV cameras (Loukaitou-Sideris et al., 2009). Conversely, peak-hour overcrowding may feel unsafe too (Moreira and Ceccato, 2020). In essence, timing does not create fear in a vacuum; rather, it amplifies or mitigates the safety aspects of access and surveillance.

Safety perceptions vary across Shiraz subway stations due to spatial and modal heterogeneity. Stations in dense, mixed-use areas with active frontages and high foot traffic—such as Zand or Namazi—are seen as safer than those in peripheral, car-oriented zones. Access mode also matters: women walking or using informal transport often contend with poorly lit or deserted paths, unlike those arriving by car or bus. These differences highlight the need for spatially tailored design and policy interventions across the system.

It is critical to interpret these findings within the context of our sample's demographic profile. Our study predominantly captured the views of younger, university-educated, and employed women. A stronger emphasis on surveillance may be characteristic for this group, which is comprised of more tech-savvy, mobile, and independent members. Solo travel for work or education during a wider range of hours makes formal surveillance measures like cameras and police presence more salient to their experience. Conversely, the effects of design and access may be stronger among groups that were underrepresented in the survey. For instance, older or more sedentary women may place a much higher premium on features like escalators, distance, and signage.

Table 4
Direct, indirect, and total effects.

Path	β	SD	p	β	SD	p	β	SD	p
	Direct effects			*Indirect effects (total)*			*Total effects*		
Access→Perceived safety	−0.128**	0.054	0.018				−0.128**	0.054	0.018
Demographics→Perceived safety	−0.059**	0.036	0.020				−0.059**	0.036	0.020
Timing→Perceived safety				0.276**	0.039	0.000	0.276***	0.039	0.000
Design→Perceived safety	−0.162***	0.056	0.004				−0.162***	0.056	0.004
Surveillance→Perceived safety	0.430***	0.040	0.000				0.430***	0.040	0.000
Timing→Access	−0.390***	0.053	0.000				−0.390***	0.053	0.000
Timing→Surveillance	0.526***	0.042	0.000				0.526***	0.042	0.000
				Indirect effects (specific)					
Timing→Surveillance→Perceived safety				0.050**	0.024	0.034			
Timing→Access→Perceived safety				0.226***	0.033	0.000			

** $p < 0.05$; *** $p < 0.01$.
$N = 680$.
β: mean of coefficient estimated from the bootstrapping process.
SD: standard deviation.
p: *p*-value.

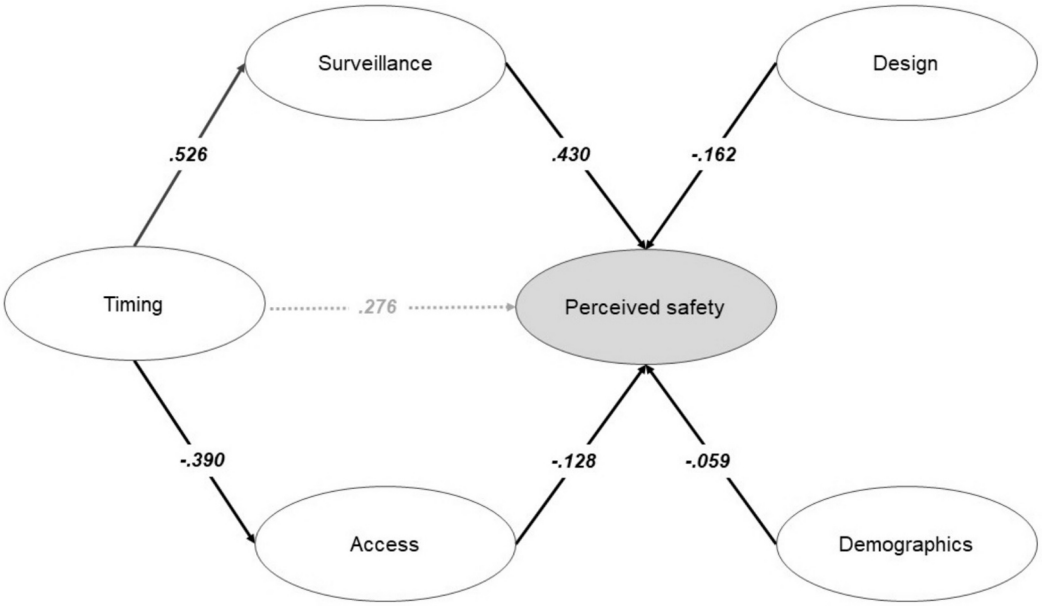


Fig. 4. Statistically significant total effects. The numbers on the arrows indicate the size of the effect. The larger the number, the stronger the effect of one construct on another. Note that the total effect of timing on perceived safety is only indirect. Image by authors.

6. Discussion

Among the findings, the 'surveillance' aspect warrants further discussion. Surveillance is widely recognised as an effective deterrent to crime, particularly when CCTV cameras are consistently maintained and actively monitored by station staff in real time[2] (Loukaitou-Sideris et al., 2009; Smith and Clarke, 2000). In some contexts, surveillance also positively impacts perceived safety, as the presence of security cameras and personnel provides a reassuring atmosphere, especially for women. In fact, a study of subway systems in U.S. cities found that female passengers preferred the presence of security officers over hardware such as cameras or emergency phones (Majd, 2013). This would suggest that increased surveillance - through CCTV, security personnel, and similar measures - could improve safety perceptions among female passengers in Shiraz.

However, surveillance measures must be weighed against ethical considerations. In Iran, where dress codes and limitations on personal freedoms are enforced, extensive CCTV use in public transport could make some women feel less free or safe due to the increased monitoring of their appearance and behaviour. Some critics argue that people are entitled to privacy and anonymity, and research supports this view. For instance, a study of Middle Eastern migrant women in Australia found that, for some participants, particularly Iranians, CCTV and police patrols provoked anxiety and insecurity, evoking unpleasant memories of constant surveillance in their home countries (Gholamhosseini et al., 2018). Finally, according to perspectives from Copenhagen's school of thought, excessive surveillance can potentially signal high crime levels to passengers and thus provoke more fear (Buzan et al., 1998; Svitková, 2014). Given these considerations, in Shiraz, enhanced surveillance measures may not necessarily be the most effective strategy for improving safety perceptions among female passengers.

[2] In many cases, cameras simply film and store information to provide evidence if incidents occur.

7. Conclusion

Based on our findings, we recommend a series of interventions which could help female subway users – in Iran and farther afield - feel safer. We reference the authors who originally proposed these solutions, but it is important to acknowledge that these approaches remain untested in the Iranian context. While these interventions have shown promise in other settings, their applicability and effectiveness in Iran's unique legal, social, and cultural environment have yet to be explored. Thus, while we draw on international insights, we remain cautious and recognize the need for further investigation to validate their local relevance and impact.

Surveillance measures turned out to be important in this study, but increasing the number of CCTV cameras and security personnel may be a double-edge sword in the context of Iran. Therefore, we only recommend that station audits be performed to identify areas that require brighter illumination, such as corridors, walkways, and waiting rooms. Adequate lighting not only discourages crime but also enhances passenger comfort (Natarajan et al., 2015).

Another important aspect is *timing*. Conducting collaborative patrols during high-risk periods, such as rush hour and late nights, can reassure passengers and deter criminal activity (Ceccato, 2013). Routine testing of emergency call systems is necessary to confirm their functionality, enabling passengers to promptly report incidents and take appropriate action when needed.

To enhance *access* to public transit facilities, the walkways should be improved to ensure easy passage for pedestrians. Additionally, upgrading the crossings and overall station infrastructure is crucial to facilitate smooth and secure movement for all users.

In terms of *demographics*, it is important to provide safety information in plain language and utilize infographics to ensure that the messages are easily understood by everyone. Conducting educational workshops can further increase awareness and understanding of safety protocols. Involving the local community in these initiatives will foster a sense of ownership and cooperation.

Design improvements in areas adjacent to stations are also desirable – albeit costly – measures to enhance safety perceptions. Upgrading building quality can create a more pleasant and less stressful walking environment. Reducing the number of unsupervised parking lots can mitigate potential safety risks. Considering pedestrian access in dead-end streets ensures that all areas are accessible. Installing visible and well-illuminated signage can help passengers navigate the area more easily, offering a clear sense of direction. Moreover, incorporating design elements that enhance natural monitoring, such as unobstructed lines of sight and well-defined paths, can discourage criminal behaviour.

However, these are infrastructure-focused measures. The real challenge is to cultivate a feeling of collective responsibility for women's and girls' safety and empower female riders to confront and report perpetrators (Loukaitou-Sideris et al., 2009; Hu & Yang, 2024). This is easier said than done given Iran's legal and social constraints, including the risks of retaliation and stigma associated with reporting harassment. In this context, women-friendly reporting channels are paramount. These include anonymous hotlines, women-staffed help desks at subway and police stations, and discreet community-based monitoring—rather than direct confrontation. Collaboration with local women's organizations and male leaders in authority (e.g., religious figures, police, transit officials) is essential to legitimize reforms and challenge entrenched gender norms that enable harassment. To inform these efforts, localized, gender-sensitive data collection is critical. Surveys should routinely address harassment experiences, and be complemented by qualitative methods to explore women's fears, coping strategies, and aspirations.

While PLS-SEM analyses causal relationships, a cross-sectional study cannot establish causality. Longitudinal studies are recommended to track how women's perceptions of safety change over time in response to policy, infrastructure, and cultural shifts. Such studies can reveal the cumulative impact of repeated harassment and evaluate the long-term effectiveness of safety interventions.

Importantly, future studies should cast light on the ways in which Middle Eastern cultures and religions exacerbate or ameliorate women's perceptions of safety while in public. Findings in this area tend to be context-specific, thereby limiting any study's generalizability to other settings. Future studies set in the Middle East could integrate local factors, such as the paradoxical safeguard of male guardianship (e.g., as a moderator for constructs like 'surveillance' or 'demographics'). Researchers should account for women's self-censorship and their reluctance to report or even discuss instances of sexual harassment while using public transit systems (Roy and Bailey, 2021; Gekoski et al., 2017). Therefore, it is imperative to approach the topic with sensitivity, respecting cultural norms, ensuring confidentiality, and acknowledging potential challenges in data collection.

Criteria:
$R^2 > 0$ must be satisfied (Hair et al., 2011).
*Q2 > 0 is meaningful (*Ringle et al., 2020*)*.
SRMR <0.08 is acceptable (Hair et al., 2017).
NFI > 0.8 is acceptable (Hu and Bentler, 1998).

CRediT authorship contribution statement

Ali Soltani: Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization. **Mohsen Roohani Qadikolaei:** Writing – original draft, Formal analysis, Data curation. **Dorina Pojani:** Writing – review & editing, Writing – original draft, Visualization, Validation, Conceptualization. **Marjaneh Moeini:** Writing – original draft, Investigation, Formal analysis, Data curation. **Kamyar Abdekhoda:** Writing – original draft, Investigation, Formal analysis, Data curation.

Declaration of competing interest

The authors declare no conflict of interest.

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Appendix A. Construct reliability, internal consistency, and convergent validity

Construct (inner model)	Indicator (outer model)	t-statistic	Factor Load	Average Variance Extracted (AVE)	Composite Reliability (rho_a)	Composite Reliability (rho_c)	Cronbach's Alpha (CA)
Perceived safety	Safety 1	9.021	0.604	0.541	0.883	0.759	0.779
	Safety 2	15.587	0.688				
	Safety 3	14.931	0.703				
	Safety 4	9.925	0.656				

(*continued on next page*)

(*continued*)

Construct (inner model)	Indicator (outer model)	t-statistic	Factor Load	Average Variance Extracted (AVE)	Composite Reliability (rho_a)	Composite Reliability (rho_c)	Cronbach's Alpha (CA)
Access	Access 1	3.129	0.507	0.528	0.871	0.74	0.699
	Access 2	2.91	0.508				
	Access 3	3.011	0.423				
	Access 4	2.548	0.466				
Demo-graphics	Demographics 1	4.674	0.629	0.573	0.883	0.787	0.738
	Demographics 2	1.949	0.424				
	Demographics 3	7.845	0.79				
	Demographics 4	4.282	0.605				
Design	Design 1	14.598	0.884	0.576	0.903	0.771	0.73
	Design 2	6.837	0.662				
	Design 3	3.255	0.463				
	Design 4	8.992	0.745				
Surveillance	Surveillance 1	7.555	0.506	0.591	0.824	0.757	0.698
	Surveillance 2	19.425	0.742				
	Surveillance 3	9.809	0.61				
	Surveillance 4	19.329	0.735				
	Surveillance 5	5.287	0.486				
Timing	Timing 1	9.82	0.655	0.505	0.884	0.755	0.697
	Timing 2	17.93	0.767				
	Timing 3	33.067	0.849				
	Timing 4	5.794	0.402				
	Timing 5	4.055	0.455				

Criteria:

Internal Consistency: 0.7 ≤ Composite Reliability (rho_c) ≤ 0.95 (DeVellis, 2017; Hair et al., 2019; Ringle et al., 2020). For exploratory research, minimum acceptable level is 0.6 (Hair et al., 2019).

Composite Reliability (rho_a): rho_a ≥ 0.7 (Hair et al., 2022).

Convergent Validity: Average Variance Extracted (AVE) ≥ 0.5 (Chin, 1998).

Appendix B. Discriminant validity

Construct	Fornell-Larcker Criterion						Heterotrait-Monotrait Ratio (HTMT)					
	Access	Demographics	Design	Safety	Surveillance	Timing	Access	Demographics	Design	Safety	Surveillance	Timing
Access	0.477											
Demographics	0.069	0.611					0.805					
Design	0.455	0.531	0.690				0.826	0.814				
Safety	−0.356	−0.209	−0.367	0.664			0.612	0.384	0.426			
Surveillance	−0.349	−0.129	−0.268	0.526	0.625		0.612	0.424	0.387	0.811		
Timing	−0.390	−0.063	−0.273	0.607	0.526	0.637	0.813	0.391	0.480	0.850	0.841	

Criteria:

Fornell-Larcker Criterion: $\sqrt{AVE}$ in every construct > other correlation values among other constructs (Fornell and Larcker, 1981). For AVE values, see Appendix 1.

Heterotrait-Monotrait Ratio (HTMT) ≤ 0.85 (Henseler et al., 2015).

Appendix C. Collinearity among constructs (VIF values)

Construct	*Perceived safety*	*Access*	*Demographics*	*Design*	*Surveillance*	*Timing*
Perceived safety						
Access	1.434					
Demographics	1.474					
Design	1.859					
Surveillance	1.161					
Timing		1.000			1.000	

Acceptable variance inflation factor (VIF) values <5 (Kim, 2019).

Appendix D. Collinearity among indicators

Indicator	*VIF**
Safety 1	1.119
Safety 2	1.116
Safety 3	1.223
Safety 4	1.206
Access 1	1.113
Access 2	1.097
Access 3	1.010
Access 4	1.072
Demographic 1	1.050
Demographic 2	1.037
Demographic 3	1.332
Demographic 4	1.300
Design 1	4.909
Design 2	4.119
Design 3	1.561
Design 4	1.889
Surveillance 1	1.133
Surveillance 2	1.303
Surveillance 3	1.167
Surveillance 4	1.349
Surveillance 5	1.052
Timing 1	1.302
Timing 2	1.461
Timing 3	1.781
Timing 4	1.050
Timing 5	1.043

* Acceptable Variance Inflation Factor (VIF) values <5 (Kim, 2019).

Data availability

The data that has been used is confidential.

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