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Travel adaptations among women commuters in response to sexual harassment and fear of crime on public transport

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A B S T R A C T

Promoting public transport is widely regarded as a key strategy for advancing sustainability. However, concerns about women's safety continue to pose a significant barrier to its regular use. A growing number of studies have highlighted the vulnerability of female commuters to harassment and crime, yet there is limited evidence on how these experiences –and the fears they generate– translate into changes in travel behavior. This knowledge gap makes it difficult to develop evidence-based interventions. Accordingly, this study examined the interrelations between sexual harassment, fear of crime, and travel-related behavioral adaptations among female public transport users in Spain. The analysis was based on a cross-sectional sample of 720 female public transport commuters. The average age of participants was 29 years. They responded to an e-survey addressing commuting patterns, perceptions of safety, and behavioral responses. Our results suggest that both direct and indirect experiences of harassment are consistently associated with higher levels of fear of crime, which in turn influence changes in travel behavior. Specifically, fear of crime was found to partially mediate the relationship between harassment and travel-related adaptations. These findings provide further insight into how psychological and contextual factors shape women's use of public transport, and highlight the need to address not only actual incidents but also the broader perception of insecurity.

1. Introduction

Public transport stands out as an attractive and sustainable mobility option, given its relatively low crash rates, role in supporting urban mobility, and environmental benefits (World Health Organization, 2012; Watkins, 2018). Yet, despite these advantages, its broader adoption continues to depend on addressing persistent barriers that deter many users from relying on it for their daily travel needs (Orozco-Fontalvo et al., 2019; Soto et al., 2022). Among these deterrents, perceptions of insecurity –including fear of harassment or crime– have been identified as key factors shaping users' travel decisions (Alfaro et al., 2025; Basu et al., 2022; Ceccato et al., 2023, 2024a; King et al., 2023; Kutela et al., 2024).

Although crime and violence in transit environments have been studied in several countries, important questions remain about how women, in particular, respond to such threats. Several studies have repeatedly shown that many women feel unsafe during specific parts of their trips – for example, while waiting at stations, walking to or from stops, or on-board public transport vehicles (Ceccato et al., 2021, 2024a; Sundling et al., 2024; Walsh, 2020). In this context, the present study examines how sexual harassment, fear of crime, and behavioral adaptations are interrelated, with a focus on the Spanish setting, where empirical research on this topic remains limited.

1.1. Fear of crime and fear of sexual crime

Perceived security remains one of the key psychological factors influencing the use of public transport (Alfaro et al., 2025; Loukaitou-Sideris & Fink, 2009). Among vulnerable population segments in particular, the decision to rely on transit services is shaped not only by actual crime statistics but also by individuals' perceived likelihood of victimization. Fear of crime (FoC) is generally understood as a multidimensional construct involving both emotional reactions and cognitive risk assessments. It may lead to behavioral changes such as altering travel routes, avoiding certain journeys, or increased vigilance while commuting (Ison et al., 2023; Lorenc et al., 2013). These responses are particularly common among women and other groups exposed to greater vulnerability in transit settings (Alonso et al., 2020; Hidalgo et al., 2020).

Following this evidence-based approach, previous research has shown that fear of crime is especially prevalent in transit environments, including vehicles, stations, and other facilities, potentially observed during both service and off-service hours (Alonso et al., 2020; Basu et al., 2023; Ceccato et al., 2013; Khademi et al., 2024; Useche et al., 2024). Previous studies, such as those by Cozens et al. (2004) and Currie et al. (2013), have raised concerns about how increasing fear of crime rates can impact the effectiveness, adoption, and satisfaction with public transport services.

FoC has various determinants and consequences, with some being particularly common across the literature, especially in relation to FoC's risk and vulnerability correlates (Macassa et al., 2023; Riordan, 1999; Türk et al., 2023). From an empirical perspective, it is known that fear of crime tends to be shaped by several personal and contextual factors, including gender, age, social background, and previous exposure to harassment or aggression. Women often report higher FoC levels than men, especially in spaces with low visibility, poor lighting, or limited oversight (Spicer and Song, 2017; King et al., 2023). Beyond general fears, the literature has increasingly distinguished fear of sexual crime (FoSC) as a separate construct, acknowledging the specific nature of non-consensual behavioral expressions such as catcalling, physical harassment, or inappropriate touching, which disproportionately affect female travelers (Dunckel-Graglia, 2013; Ison et al., 2023; Moyano et al., 2025).

Although large-scale data are limited, recent figures from countries like the UK estimate that nearly a third of women commuting via public transport have been sexually harassed – many without receiving help from either staff or bystanders (British Transport Police, 2023). In Spain, reports also suggest that women are the main victims of harassment during commutes, though public awareness and systematic responses remain limited (European Investment Bank, 2023).

1.2. Consequences of sexual violence 'on the move'

The consequences of harassment are not limited to discomfort or one-time disturbances. Repeated exposure to threatening situations in transit spaces has been linked to increased psychological distress, including symptoms of anxiety, depression, and substance use (Östergren et al., 2022; Reed et al., 2019). Such outcomes are often compounded by stress responses like hypervigilance, especially in women who experience or witness harassment in public spaces (Ceccato and Loukaitou-Sideris, 2020; Ison et al., 2023).

On a behavioral level, many women adapt their travel patterns to manage perceived risks. These changes can include avoiding certain lines or stops, modifying travel schedules, avoiding traveling alone, or choosing longer routes perceived as 'safer' (Currie et al., 2013; Monteiro et al., 2021; Sil et al., 2024). While these adaptations may help commuters feel safer, they often increase travel time and effort, and may reduce access to work, education, or leisure opportunities (Quigg et al., 2024; Bauer, 2021). Importantly, daily commuting (e.g., working, studying, caring) women may be especially affected, as they often lack

the flexibility to avoid transit use altogether.

The present study focuses on these behavioral adaptations and their associations with both experienced and witnessed harassment, as well as with perceptions of safety. This approach allows us to better understand how risk perceptions extend beyond direct victims and affect broader commuter populations.

1.3. Study aim and hypotheses

As aforementioned, the aim of this study was to examine the interrelations between sexual harassment, fear of crime, and travel-related behavioral adaptations among female public transport users in Spain.

Hypothesis 1. Sexual harassment, fear of crime, and travel behavioral adaptations are significantly associated among female public transport commuters.

Hypothesis 2. There will be significant differences in sexual harassment, fear of crime, and behavioral factors based on women's age and their history of harassment witnessing (bystander role) and/or victimization (victim role) in public transport.

Hypothesis 3. Fear of crime statistically mediates the relationship between harassment experiences (witnessed or suffered) and behavioral adaptations, operationally manifested in alterations to travel patterns, even if these changes are less convenient or require greater effort, as a response to FoC.

Following the directional associations among these studies suggested by the literature, the model framework is presented in Fig. 1.

2. Methods

2.1. Participants

This study was based on data collected from a nationwide sample of 720 women who regularly commute using public transport in urban areas across Spain's 17 Autonomous Communities. The average age of participants was 29 years ($SD = 12.3$). Their reported daily commuting time, including round trip, averaged approximately 74 min ($SD = 49.5$). Additional demographic characteristics of the participants, including age distribution, education, and commuting mode, are presented in Table 1.

2.2. Procedure

The data were collected through an electronic survey conducted in 2023. The sample was obtained using a non-probabilistic (convenience) method based on a research participant database shared by 23 universities and institutions across Spain. Individuals included in this database had previously agreed to participate in mobility-related studies.

Survey invitations were emailed to potential participants, with eligibility criteria clearly stated: being a woman, commuting at least once a week, and using public transport. The survey was presented in Spanish, and participants were required to provide informed consent before proceeding. All participants were informed that their data would be treated confidentially and used exclusively for scientific purposes.

This online approach was selected to facilitate wide participation and to align with ongoing safety protocols and logistical constraints. Although the sampling was not random, the sample characteristics showed acceptable alignment with national census data on female education levels. For instance, 27 % of the sample reported secondary education or lower, compared to the national estimate of 32 %. Regarding university-level education, 54 % of participants had completed undergraduate degrees, close to the national average of 45–57 % (INE, 2023).

It is worth noting that our sample skews somewhat younger than the general working female population in Spain, whose average age
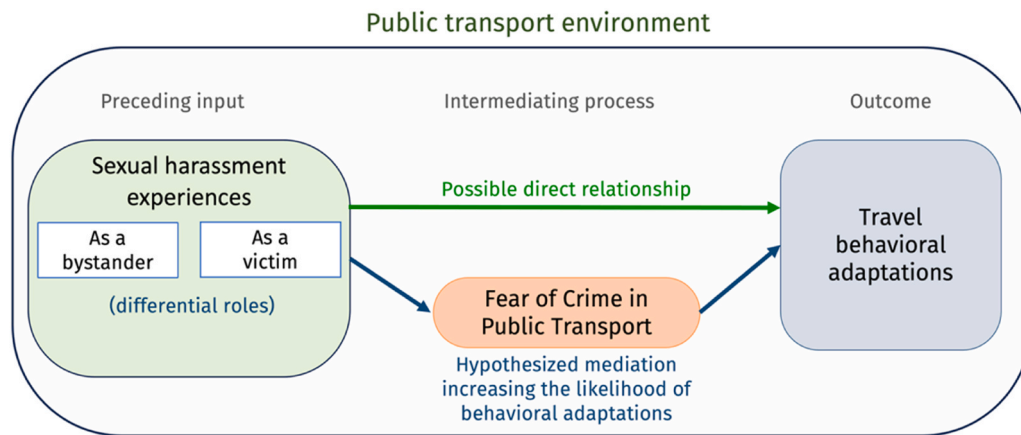
Public transport environment

Fig. 1. Theory-based schematic model for testing the role of Fear of Crime in the relationship between harassment experiences and travel behavioral adaptations.

Table 1
Sociodemographic details and characteristics related to commuting trips of the study participants.

Variable	Label	Frequency (n)	Percentage (%)
Age Group	≤ 25 years	427	59.3 %
	26–50 years	225	31.3 %
	> 50 years	68	9.4 %
Educational level	Primary studies or lower	25	3.5 %
	Secondary-high school	169	23.5 %
	Technical studies	67	9.3 %
	University studies	389	54.0 %
	Post-graduate studies	70	9.7 %
Occupation	Student commuter	430	44.9 %
	Working commuter	207	37.3 %
	Independent work commuter	23	3.2 %
	Other commuting reason (e.g., care, volunteering)	60	8.3 %
Most frequent commuting transport mode	Bus	392	54.4 %
	Metro or tram	296	41.1 %
	Other (e.g., intermodal)	32	4.4 %
Daily commuting time (round trip)	< 1 h	231	32.1 %
	1–1.9 h	234	32.5 %
	2–2.9 h	100	13.9 %
	3–3.9 h	17	2.3 %
	> 4 h	19	2.6 %
	N/R	119	16.5 %

typically ranges between 41 and 45 years. However, given that younger individuals tend to use public transport more frequently, this age distribution is consistent with the study context.

Lastly, the online format was unlikely to limit access significantly: over 93 % of adults in Spain report regular internet use, and this figure rises to 98 % among employed individuals (INE, 2023; 2024). The estimated response rate was around 40 %, based on the total number of invitations sent.

2.3. Description of the survey tool

The electronic questionnaire used to gather data for this study consisted of four main sections, structured as follows:

The first section addressed demographic and trip-related data of female commuters. It inquired about basic social and individual information, including gender (research filter), age, city of origin, educational attainment, current occupation, and commuting features, such as modality/vehicle(s) used, frequency, trip length, and daily commuting trip length.

Secondly, participants were asked how often they had witnessed or experienced harassment in public transport contexts (vehicles, stops,

stations, or during access routes) over the past year. Four items measured each type of experience, using a five-point scale (0 = Never, 4 = Very frequently). The internal consistency of these scales was evaluated using three consistency measures, aimed at assessing of how reliably a scale captures the same construct across its items: Cronbach's alpha (α), McDonald's omega (ω), and Composite Reliability Index (CRI). For witnessed harassment, α = .83, ω = .84, CRI = .92. For experienced harassment, α = .85, ω = .85, CRI = .93.

Fear of Crime was estimated in probabilistic terms using a multiple integrated choice list of possible crime-related situations in public transport environments, using a 5-point scale [0 = not likely at all; 4 = very likely]. Respondents were presented with a total of 12×2 (12 situations during the day and night) different hypothetical choice situations, with 6 corresponding to common offenses (e.g., robbery, aggression) and 6 to sexual offenses (e.g., undesired exhibitions, verbal harassment/catcalling, physical harassment/touches). The full-length version of the scale and its related statements is available in Soto et al. (2022). To avoid overlapping content between predictors, FoC and FoSC were analyzed separately. Reliability measures for general FoC were α = .92, ω = .92, CRI = .96; and for FoSC: α = .95, ω = .95, CRI = .96.

Behavioral adaptations consisted of a list of five literature-based personal security-related behavioral changes usually documented in response to crime-related experiences or perceptions, which were compatible with mass public transport settings. These included: (intentionally) changing transport mode; avoiding traveling alone; avoiding crowded vehicles; avoiding empty vehicles; changing travel routes or routines. Responses were on a 0–1 scale (0 = No, 1 = Yes). The internal consistency for this subscale was α = .67, ω = .66, CRI = .84.

All exposure, perception, and behavior questions referred to the previous 12-month (1 year) period to ensure temporal consistency across sections.

2.4. Ethics

To carry out this study, two relevant bodies were consulted: First, the research protocol was assessed and approved by the Research Ethics Committee at the INTRAS (University Research Institute for Traffic and Road Safety), University of Valencia, in accordance with the Declaration of Helsinki (IRB approval number HE0002140923). Additionally, the gender, diversity, and inclusiveness features of the research were reviewed and endorsed by the Research Committee on Equity, Inclusion, and Gender issues of the INTRAS (University Research Institute for Traffic and Road Safety), University of Valencia (IRB grant EIG0001031023).

2.5. Data analysis

After curating the data, the survey responses were coded following the guidelines of each subscale. Categorical variables (e.g., age group, exposure type) were labeled accordingly. Basic descriptive statistics (means, standard deviations) and reliability tests (Cronbach's alpha and McDonald's omega; see Dunn et al., 2014) were computed using SPSS v28.

After calculating basic mean and dispersion scores for the continuous variables, the second step was to test the coherence and magnitude of the bivariate relationships, including ordinal factors. This implied the use of parametric (Spearman's rho_s) instead of non-parametric (Pearson's r_s) correlations to measure inter-factor associations.

To explore the role of harassment exposure, participants were grouped into four exposure-based categories based on whether they had witnessed or experienced harassment. This allowed for comparative analysis between subgroups. Age comparisons and harassment group differences were analyzed using Welch's ANOVA (West, 2021) with Tukey HSD post-hoc tests, which are appropriate for samples with unequal variances or sizes, typical from questionnaire-based settings (see Abdi and Williams, 2010).

Finally, a Structural Equation Model (SEM) was tested using SPSS AMOS v28. This confirmatory (literature insight-based) method aimed to examine direct and mediated relationships between harassment experiences, fear of crime, and behavioral adaptations, controlling for age, education, trip length, and city size. Bootstrapping methods were applied to obtain bias-corrected estimates and reduce the risk of Type I errors.

3. Results

3.1. Descriptive data and bivariate correlations

Table 2 shows the descriptive statistics and bivariate (Spearman) correlations between the study variables. On average, they reported moderate levels of fear of crime in public transport environments, with a mean of 2.26 ($SD = 1.06$), and a mean of 1.72 behavioral adaptations in response to crime-related concerns ($SD = 1.41$).

Among the significant bivariate correlations among the study factors, there stands out that age was negatively correlated with the frequency of both witnessed and suffered harassment ($rho = -.203$ and $-.154$, respectively; $p < .001$) and with general fear of crime ($rho = -.106$; $p = .004$). Moreover, no significant correlation was found between age and the number of self-reported behavioral adaptations in the last year

($p = .268$).

Fear of crime was significantly and positively correlated with the frequency of witnessed ($rho = .388$) and suffered harassment ($rho = .353$), as well as with behavioral adaptations ($rho = .244$), all with $p < .001$. The correlation between suffered harassment and behavioral adaptations ($rho = .236$) was also significant, suggesting coherent links between harassment, fear of crime, and changes in travel behavior.

3.2. Age comparisons and post-hoc analyses

Women aged ≤ 25 years reported the highest average level of witnessing harassment ($M = 1.70$), followed by those aged 26–50 ($M = 1.47$), while women over 50 reported a substantially lower mean ($M = .76$). Differences between the three groups were statistically significant ($p < .001$). Regarding suffered harassment, women in the ≤ 25 and 26–50 groups showed similar mean values ($M = 1.20$ and 1.15, respectively), both notably higher than those reported by women over 50 ($M = .50$), with differences reaching statistical significance ($p < .001$).

The average scores for fear of sexual crime (FoSC) also varied across age categories. Participants aged ≤ 25 years reported a mean of 2.36, those aged 26–50 reported 2.19, and those over 50 reported 1.89. These differences were statistically significant ($p < .010$). In terms of behavioral adaptations, women aged 26–50 reported the highest average number of changes ($M = 1.72$), followed by those ≤ 25 ($M = 1.50$) and those over 50 ($M = 1.11$).

All group scores had significant post-hoc differences among them ($p < .001$). Fig. 2 and Table 3 present the full-length results of robust ANOVA tests comparing perceptions and behaviors across age groups (≤ 25, 26–50, and >50 years).

3.3. Cluster comparisons by harassment experience

With the aim of differentiating the mean levels of sexual and non-sexual fear of crime (FoC) and the number of travel-related behavioral adaptations among female public transport commuters, a cluster analysis was performed based on their reported experiences of sexual harassment over the last year. Specifically, participants were grouped using a 2×2 classification approach combining the dichotomous variables of having witnessed and/or suffered harassment. This resulted in the creation of four participant clusters, which were later compared using weighted analyses, adjusting for age and commuting frequency.

The distribution of participants across these clusters was as follows: Cluster 1 included $n_1 = 133$ women (18.5 %) who neither witnessed nor

Table 2

Basic descriptive data and bivariate (Spearman) correlations between study variables.

	Variable	Mean(SD)	Statistic	Age (years)	Educational attainment	Witnessed sexual harassment	Suffered sexual harassment	FoC in Public Transport
1	Age (years)	28.94 (12.28)	rho Sig.	–				
2	Educational attainment[a]	–	rho Sig.	−.096* .011	–			
3	Witnessed sexual harassment[b]	1.54(1.23)	rho Sig.	−.203** < .001	.134** < .001	–		
4	Suffered sexual harassment[b]	1.12(1.14)	rho Sig.	−.154** < .001	.077* .040	.690** < .001	–	
5	FoC in Public Transport (General)[b]	2.26(1.06)	rho Sig.	−.106** .004	.079* .035	.388** < .001	.353** < .001	–
6	Travel behavioral adaptations[c]	1.72(1.41)	rho Sig.	−.041 .268	.022 .548	.162** < .001	.236** < .001	.244** < .001

Notes for the Table:
[a] Corresponds to an ordinal variable;
[b] Measured in a [0−4] scale;
[c] Measured in a [0−5] scale, as this refers to actual self-reported behaviors;
* Correlation is significant at the 0.05 level (2-tailed);
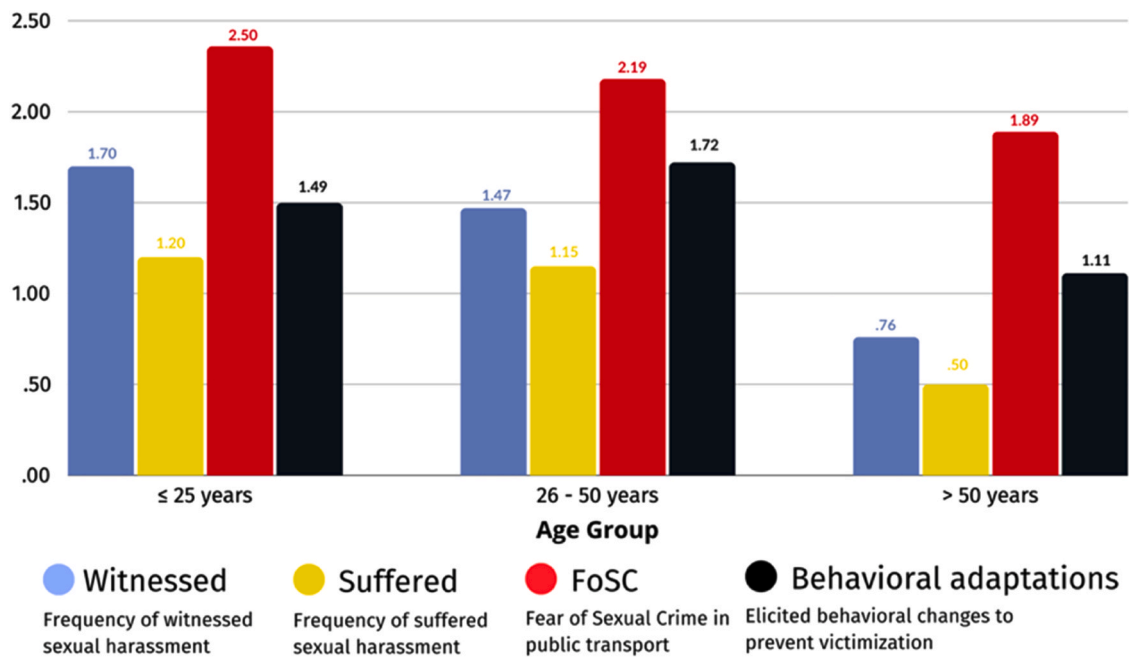** Correlation is significant at the 0.01 level (2-tailed).

Fig. 2. Graphical differences in sexual harassment witnessing and suffering (frequency), fear of sexual crime, and travel behavioral adaptations among age groups.

Table 3
Descriptive values and robust mean comparisons according to commuters' age group for perceptual and behavioral factors.

Study Variable	Age Group	Mean	SD	SE	95 % CI[a]		Comparative Tests		Effect Sizes[b]		95 % CI[a]	
					Lower	Upper	Test value[c]	Sig.[d]	Parameter	Estimate	Lower	Upper
Witnessing of Harassment	≤ 25	1.700	1.268	.061	1.580	1.820	23.547	***	η^2	.049	.022	.082
	26–50	1.470	1.115	.074	1.330	1.620			ε^2	.046	.019	.079
	> 50	.760	1.009	.122	.520	1.010			Ω_F^2	.046	.019	.079
	Total	1.540	1.228	.046	1.450	1.630			Ω_R^2	.024	.010	.041
Suffering of Harassment	≤ 25	1.200	1.151	.056	1.090	1.310	19.646	**	η^2	.031	.010	.058
	26–50	1.150	1.148	.077	1.000	1.300			ε^2	.028	.007	.056
	> 50	.500	.820	.099	.300	.700			Ω_F^2	.028	.007	.056
	Total	1.120	1.140	.042	1.040	1.200			Ω_R^2	.014	.004	.029
FoSC in Public Transport Environments	≤ 25	2.364	1.038	.050	2.265	2.462	6.351	**	η^2	.018	.003	.041
	26–50	2.186	1.070	.071	2.046	2.327			ε^2	.016	.000	.038
	> 50	1.895	1.101	.134	1.628	2.161			Ω_F^2	.016	.000	.038
	Total	2.264	1.062	.040	2.186	2.342			Ω_R^2	.008	.000	.019
Behavioral Adaptations	≤ 25	1.499	1.360	.052	1.309	1.596	9.525	***	η^2	.016	.004	.032
	26–50	1.721	1.487	.075	1.572	1.870			ε^2	.014	.002	.030
	> 50	1.112	1.327	.119	.877	1.347			Ω_F^2	.014	.002	.030
	Total	1520	1.409	.041	1.447	1.607			Ω_R^2	.007	.001	.015

Notes: SD= Standard Deviation; SE= Standard Error;
  [a] Confidence Interval at the level 95 %;
  [b] Estimated based on the fixed-effect model;
  [c] Test value;
  [d] Significance levels:
*** = <.001;
** = <.010; η^2= Eta-squared; ε^2= Epsilon-squared; Ω_F^2 Omega-squared (Fixed-effect); Ω_R^2= Omega-squared (Random-effect).

experienced sexual harassment in the previous year. Cluster 2 comprised $n_2 = 121$ participants (16.8 %) who witnessed but did not suffer harassment. Cluster 3 consisted of $n_3 = 22$ women (3.1 %) who reported experiencing harassment without having witnessed it. The largest group, Cluster 4, involved $n_4 = 444$ participants (61.7 %) who both witnessed and suffered harassment while using public transport during the same time frame.

Once the four clusters were defined, comparisons were made in the mean scores of general fear of crime (FoC), fear of sexual crime in public transport environments (FoSC), and the number of behavioral adaptations reported. These comparisons were carried out using robust Welch's tests followed by HSD post-hoc analyses. Because the clusters

themselves were formed based on harassment-related experiences, these two variables were not included in the analysis to avoid endogeneity and reduce the risk of biased interpretations.

Detailed descriptive and inferential statistics, including 95 % confidence intervals and effect size measures, are provided in Table 4.

Statistically significant differences were observed in both Fear of Crime variables (FoC and FoSC) across the four clusters. Women in Cluster 4, who had both witnessed and experienced sexual harassment during the last year, reported the highest averages (FoC $M_4 = 2.46$; FoSC $M_4 = 2.47$), while those located in Cluster 1, who neither witnessed nor suffered such events, reported the lowest rates in these regards (FoC $M_1 = 1.73$; FoSC $M_1 = 1.58$). Post-hoc analyses revealed significant

Table 4

Descriptive values and robust mean comparisons according to commuters' clustered sexual harassment experiences.

Factor	Cluster	Mean	SD	SE	95 % CI[a]		Comparative Tests		Effect Sizes[b]		95 % CI[a]	
					Lower	Upper	Test value[c]	Sig.[d]	Parameter	Estimate	Lower	Upper
FoC General	C_1: None	1.734	1.192	.103	1.530	1.939	29.174	***	η^2	.071	.036	.106
	C_2: Witnessed	2.122	.921	.084	1.956	2.288			ε^2	.067	.032	.102
	C_3: Suffered	2.239	1.045	.223	1.775	2.702			Ω_F^2	.067	.032	.102
	C_4: Both (W+B)	2.462	.999	.047	2.369	2.556			Ω_R^2	.023	.011	.037
	Total	2.264	1.062	.040	2.186	2.342						
FoSC in Public Transport Environments	C_1: None	1.576	1.288	.112	1.354	1.798	18.120	***	η^2	.081	.044	.118
	C_2: Witnessed	2.004	1.145	.105	1.796	2.212			ε^2	.077	.040	.114
	C_3: Suffered	2.227	1.032	.220	1.770	2.685			Ω_F^2	.077	.040	.114
	C_4: Both (W+B)	2.469	1.176	.056	2.359	2.580			Ω_R^2	.027	.014	.041
	Total	2.218	1.237	.046	2.127	2.309						
Behavioral Adaptations	C_1: None	1.308	1.321	.115	1.082	1.535	18.338	***	η^2	.072	.037	.108
	C_2: Witnessed	1.202	1.062	.097	1.009	1.395			ε^2	.068	.033	.105
	C_3: Suffered	2.900	1.744	.390	2.084	3.716			Ω_F^2	.068	.033	.104
	C_4: Both (W+B)	1.932	1.425	.068	1.798	2.065			Ω_R^2	.024	.011	.037
	Total	1.720	1.411	.053	1.616	1.824						

Notes: SD= Standard Deviation; SE= Standard Error; [a] Confidence Interval at the level 95 %; [b] Estimated based on the fixed-effect model; [c] Test value; [d] Significance levels: ***= <.001; **= <.010; η^2= Eta-squared; ε^2= Epsilon-squared; Ω_F^2 Omega-squared (Fixed-effect); Ω_R^2= Omega-squared (Random-effect).

differences between these groups (FoC $MD_{4-1} = 0.314$; p < .001; FoSC $MD_{4-1} = 0.428$; $p < .001$).

Regarding travel behavioral adaptations, significant overall differences were found, with Cluster 3 reporting the highest average number of travel-related changes ($M_3 = 2.90$), while the lowest was reported by women who only witnessed such incidents ($M_2 = 1.20$). There was also a significant post-hoc difference between these two specific groups of female travelers ($MD_{3-2} = 1.592$; $p < .001$). Fig. 3 provides a comprehensive display of trends and differences in all three compared variables.

3.4. Structural analysis

To test the directional hypotheses concerning the effects of sexual harassment on both fear of crime in public transport environments and

travel-related behavioral adaptations, a theory-driven SEM model was built. The model controlled for age, educational attainment, commuting time, and city size.

The modeling procedure followed two steps. In the first, direct paths were specified from the frequency of witnessed and suffered harassment to both fear of crime and reported behavioral adaptations. In the second step, a path from fear of crime to behavioral adaptations was added, to assess the potential mediating role of perceived insecurity between harassment exposure and behavioral responses. This structure follows the theoretical assumptions from prior literature. The model showed satisfactory fit indices: $\chi^2 = 19.779$, p < .001; NFI = .982; CFI = .985; IFI = .986; RMSEA = .057 (90 % CI [.034–.083]).

Given both theoretical consistency and acceptable goodness-of-fit, the model was retained. As described in the data analysis section,
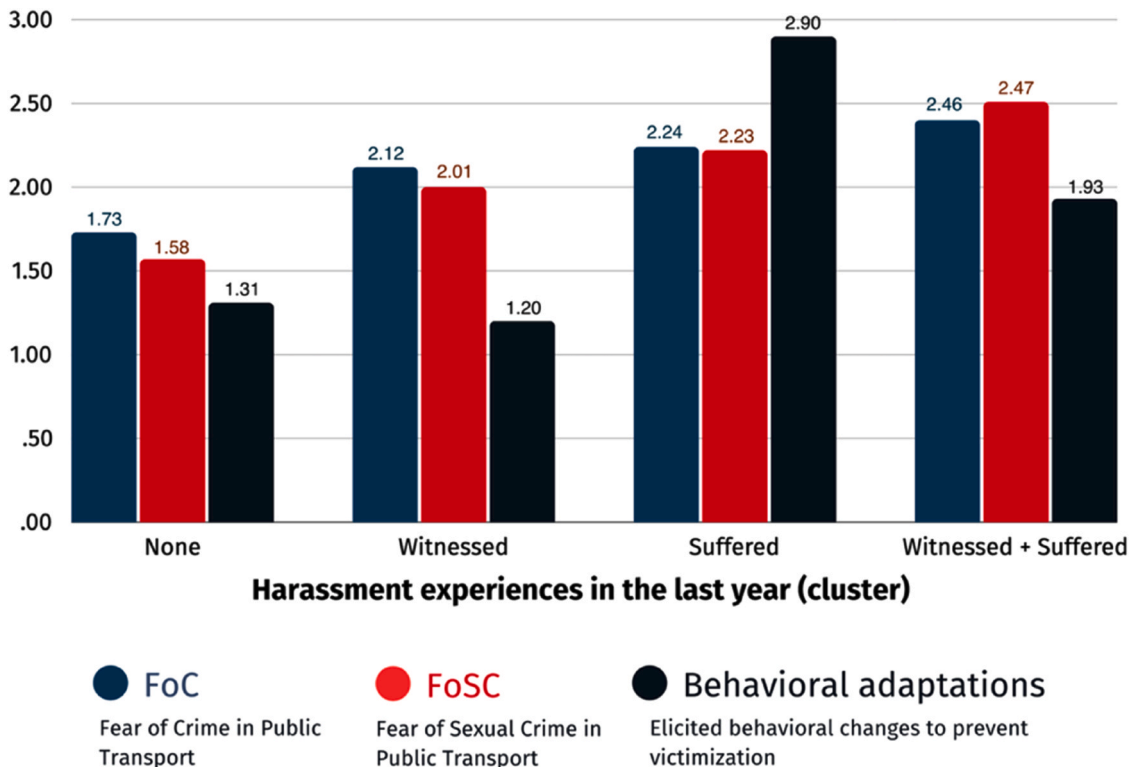

Fig. 3. Graphical differences in fear of crime, fear of sexual crime, and travel behavioral adaptations among the composed witnessing and victimization clusters.

bootstrapping techniques were used to reduce estimation bias and minimize the risk of Type I error in assessing path coefficients. Table 5 displays the standardized and bias-corrected estimates for each path, while the model structure is graphically depicted in Fig. 4. In this figure, significant paths are marked with solid arrows.

The final model included thirteen paths, eight of which corresponded to control variables. Among these, only city size showed a significant effect on behavioral adaptations (β =.087, *p* < .050), indicating a small positive association. Other control variables –age, education, and commuting time– were not significantly linked to women's self-reported behavioral adaptations.

As for the main variables of interest, both witnessed and suffered harassment were positively and significantly associated with fear of crime. Notably, the standardized path coefficient for witnessed harassment (β =.26) was slightly larger than that for suffered harassment (β =.16), suggesting a stronger contribution of indirect exposure to perceived insecurity. Although the absolute difference between these coefficients is modest, it may still carry practical relevance when identifying patterns of perceived risk in transit settings – especially among those who observe incidents without being directly involved.

However, only suffered harassment was directly associated with behavioral adaptations (β =.21; *p* < .001); the path from witnessed harassment to adaptations was not statistically significant (β = –.06; *p* = .23). Fear of crime, in turn, showed a significant and positive effect on behavioral adaptations (β =.19; *p* < .001), supporting its hypothesized role as a mediator.

Finally, the mediation analysis outcomes suggest that fear of crime fully mediated the association between witnessed harassment and behavioral adaptations, while partially mediating the effect of suffered harassment on behavioral change. In this second case, the direct effect remained statistically significant, though the mediated pathway also contributed meaningfully to the overall relationship.

4. Discussion

The accumulated evidence indicates that women's experiences of safety, or the lack thereof, in transit environments not only affect their mobility but also their access to social and economic opportunities, ultimately impacting their overall well-being (King et al., 2021). Moreover, in recent years, the significance of understanding women's issues in public transport environments has become increasingly valuable for both transport planning and social welfare, even though the body of evidence in this regard remains considerably scarce.

To help fill this gap, the present paper explored the relationships between sexual harassment, fear of crime (encompassing both sexual and non-sexual fears), and changes in travel behavior among daily public transport commuters in Spain. These objectives were framed around three hypotheses: (H1) that harassment, fear of crime, and travel behavioral adaptations are significantly associated; (H2) that significant differences in these variables exist depending on age and harassment exposure type; and (H3) that fear of crime mediates the relationship between harassment exposure and behavioral adaptations.

4.1. Perception of transport security, fear, and behavioral adaptations

The first hypothesis was supported by a set of directionally and significantly coherent associations. These findings suggest that there are robust relationships among sexual harassment, fear of both sexual and non-sexual crime, and travel behavior changes, in line with empirical studies conducted in Latin America (Alonso et al., 2020; Soto et al., 2022), Europe (Moreno et al., 2022), and Asia (King et al., 2021, 2023; Sil et al., 2024; Valan, 2020). Additionally, the results reinforce the practical relevance of enhancing perceived safety in increasing the use of public transport systems, as safety perceptions significantly shape commuter behavior (Basu et al., 2023; Cendales et al., 2023; Ison et al., 2023; Rod et al., 2023).

While the strength of some associations was modest –such as the slightly higher predictive value of witnessed harassment over suffered harassment on fear of crime (β =.098)– they remain theoretically and practically relevant. From the perspective of public transport planning, even small effects may inform early interventions focused on perceived safety improvements, which could have a multiplier effect on commuter behavior and overall accessibility.

The findings also highlight the importance of addressing the psychological and behavioral impacts of underreported incidents of harassment. Notably, the study identified a consistent association between harassment exposure and fear of crime across age groups and commuting patterns (Stark and Meschik, 2018; Sundling et al., 2024; Valan, 2020). These associations extend beyond direct victims, influencing the psychological health and daily routines of bystanders as well, thereby increasing the effort required by women to perform everyday tasks (Ceccato et al., 2021; Pillinger, 2017). Another interesting implication is that it also highlights the need for moving beyond a traditional victim-centered framework and incorporate a broader view of transit insecurity that includes the experiences of witnesses.

Table 5
Variables included in the model, estimates, significance levels, and 95 % confidence intervals for bootstrap bias-corrected values of the SEM model.

Study variable			SPC[a]	S.E.[b]	C.R.[c]	*p*[d]	Bootstrap bias-corrected values[e]				
							Est[f]	SE-SE[g]	95 % CI[h]		*p*[d]
Direct effects											
Witnessed Harassment	→	Fear of Crime in Public Transport	.261	.041	5.497	**	.263	.002	.169	.353	**
Witnessed Harassment	→	Behavioral Adaptations	−.062	.011	−1.204	.229	−.061	.002	−.163	.044	.172
Suffered Harassment	→	Fear of Crime in Public Transport	.164	.044	3.504	***	.165	.001	.072	.250	**
Suffered Harassment	→	Behavioral Adaptations	.207	.012	4.199	***	.208	.001	.126	.310	**
Mediated effect											
Fear of Crime in Public Transport	→	Behavioral Adaptations	.187	.010	4.855	***	.189	.000	.107	.260	**
Statistical controls											
Age	→	Fear of Crime in Public Transport	−.030	.003	−.851	.395	−.030	.000	−.090	.041	.410
Education	→	Fear of Crime in Public Transport	.027	.034	.804	.421	.028	.020	−.049	.094	.458
Trip Length	→	Fear of Crime in Public Transport	.005	.002	.136	.892	.005	.000	−.061	.084	.985
City Size	→	Fear of Crime in Public Transport	.033	.022	.971	.331	.034	.010	−.034	.099	.376
Age	→	Behavioral Adaptations	−.017	.001	−.437	.662	−.016	.001	−.092	.048	.536
Education	→	Behavioral Adaptations	−.002	.009	−.044	.965	−.002	.000	−.070	.079	.994
Trip Length	→	Behavioral Adaptations	.014	.001	.387	.698	.014	.000	−.078	.076	.756
City Size	→	Behavioral Adaptations	.086	.006	2.403	*	.087	.001	−.028	.148	*

Notes: [a] SPC= Standardized Path Coefficients (can be interpreted as Beta-linear regression weights); [b] S.E.= Standard Error; [c] CR= Critical Ratio; [d] p-value: *significant at the level *p* < .050; **significant at the level *p* < .010; ***significant at the level p < .001; [e] Bootstrapped (bias-corrected) model; [f] Bootstrapped (bias-corrected) model standardized estimates; [g] Transformations in the Standard Error; [h] Confidence Interval at the level 95 % (lower bound – left; upper bound – right).
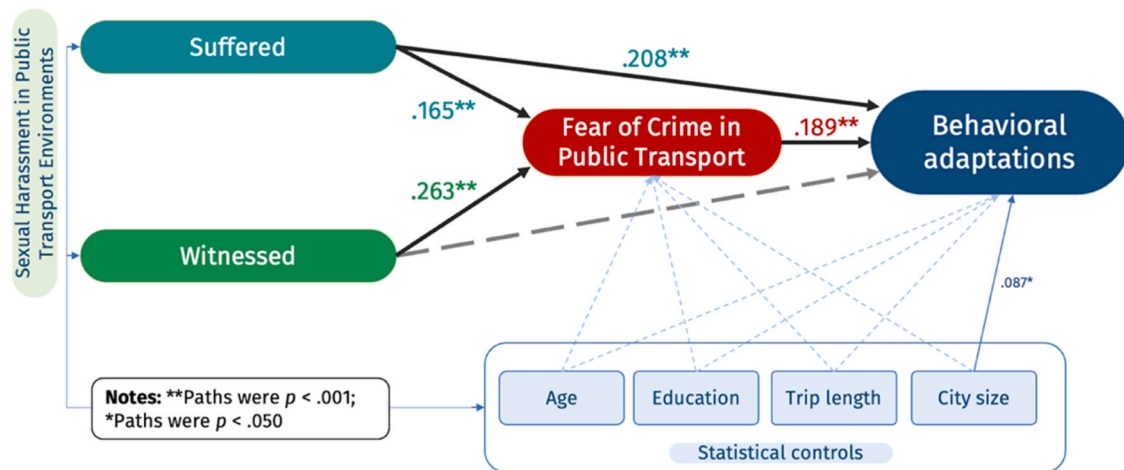
Fig. 4. SEM model - Bootstrap (bias-corrected) parameter estimates. Variables drawn in rectangles symbolize non-latent (observed) factors, while ellipses denote latent variables. All indicated estimates with solid lines are statistically significant.

4.2. Age group differences in harassment witnessing and victimization

The second hypothesis was also supported. The data suggest that younger women are more likely to experience harassment, while older women are more often observers, indicating different risk perceptions and situational awareness across age groups. These patterns align with earlier findings (Fisher and Sloan, 2003; Orozco-Fontalvo et al., 2019; Smith, 2008), which suggest that younger women often display heightened vigilance due to greater perceived risk.

Women who directly experienced harassment were more inclined to modify their travel behavior compared to those who only witnessed such incidents. This reinforces evidence that personal victimization leads to more pronounced adaptive responses (Alfaro et al., 2024; Fisher and Sloan, 2003; Khurana, 2020; Liu et al., 2023), and indicates the stronger emotional and logistical impact of direct exposure. Nonetheless, bystanders also engaged in unsought adaptations, though less frequently, supporting the notion that even indirect experiences can disrupt regular travel behavior (Cook and Fox, 2011).

4.3. Does fear of crime mediate the relationship between sexual harassment and behavioral changes?

The third hypothesis focused on the mediating role of fear of crime. The structural path model, which controlled for age, education, trip length, and city size, showed good fit and indicated significant pathways between harassment, fear of crime, and behavioral adaptations. Both types of harassment were positively associated with fear of crime, while only experienced harassment was directly associated with behavioral adaptations.

Fear of crime emerged as a complete mediator between witnessed harassment and travel changes, and a partial mediator in the case of experienced harassment. These findings point to the importance of perceived security –not just actual incidents– in shaping women's daily travel decisions (Hidalgo et al., 2020; Ceccato et al., 2022). The fact that fear of crime influenced behavioral change even in the absence of direct victimization suggests a widespread psychological effect that can disrupt commuting behavior on a broader scale.

4.4. City size "matters" for behavioral adaptations

Among the control variables, only city size was statistically associated with travel adaptations, albeit with smaller magnitude than harassment or fear of crime. The results indicate that women in larger cities were more likely to modify their travel behavior in response to safety concerns, likely due to greater access to alternative routes and

services (Ceccato et al., 2023; Cozens et al., 2004).

In Spain, this dynamic may reflect an uneven distribution of transit infrastructure and service frequency between larger urban areas and smaller cities. In smaller municipalities, limited transport options could constrain women's ability to adapt travel behavior despite safety concerns (Alfaro et al., 2024; Ferrer-Perez et al., 2021). Additionally, income and purchasing power –often higher in larger cities– may facilitate access to safer or more flexible options. Although not the central focus of this paper, these findings point to the need for further research into the structural and socioeconomic constraints that shape safety-related travel behaviors across urban contexts (Javid et al., 2024; Lorenc et al., 2013; Moreno et al., 2022).

5. Limitations of the study and further research

Although this research was conducted with a considerable and extensive nationwide sample of female commuters, using instruments that showed good psychometric properties and yielded coherent relationships among constructs, some relevant limitations should be acknowledged.

First, while all our hypotheses were based on theoretical and empirical grounds, the available evidence supporting some of these assumptions remains limited. This may affect the general strength and directionality of the outcomes. For instance, recent reviews (Useche et al., 2024) recommend caution when interpreting findings on aggression and harassment against women in public transport, as contextual factors such as ecological, cultural, and social variations may shape observed associations (Akbar and Ghazal, 2023; Forsdike et al., 2024; Freitas et al., 2023).

Second, although this study relied on self-reported experiences of harassment and behavioral adaptations, the retrospective and subjective nature of such reports may introduce memory and social desirability biases (Selaya et al., 2024). Previous research has noted similar difficulties, particularly due to the normalization or underreporting of harassment in everyday commuting contexts (Ceccato et al., 2024b; Ceccato and Loukaitou-Sideris, 2020).

Third, future studies should further explore the specific cases of female collectives (e.g., workers of specific sectors, cargegivers), non-regular or occasional female public transport users (De Oña et al., 2016; He et al., 2022). Prior evidence has shown that their mobility dynamics and perceptions of risk may differ from those of frequent users, especially in how witnessing or experiencing harassment affects their travel behavior (Heinen, 2023; Loukaitou-Sideris and Fink, 2009; Smith, 2008).

Lastly, although this study focused on women due to their higher

reported vulnerability in (among many others) transport contexts, it is important to recognize that other groups–including men, functionally diverse individuals, and gender-diverse commuters– also face transport experience- and safety-related challenges (Benya et al., 2018; Ceccato et al., 2024b; Lima-Castro et al., 2024; Sundling et al., 2024). In this regard, recent studies have pointed to the need for more inclusive safety frameworks that consider overlapping vulnerabilities and identities (Gomez-Pulido et al., 2024; King et al., 2021; Vinagre-González et al., 2023).

6. Conclusion

This study examined the associations between sexual harassment, fear of crime, and travel behavior among female public transport users in Spain, offering results that support the three initial hypotheses.

First, consistent relationships were observed between harassment experiences and higher levels of fear of crime, alongside changes in travel patterns. These findings suggest that both direct and indirect exposure to harassment may influence how women perceive safety and respond to it in their everyday mobility.

Second, there are differences across age groups regarding both the frequency of harassment exposure and the types of behavioral responses. While exposure affects all groups, travel-related changes vary depending on age and the nature of the experience, reinforcing the relevance of considering age-based distinctions when assessing transport safety.

Third, fear of crime played a relevant mediating role between harassment and behavioral adaptations. Although some of the statistical effects were modest, the results suggest that fear serves as a pathway through which safety concerns translate into concrete travel changes. These changes may lead to negative travel experiences, unsought behavioral adaptations, and reduced access to opportunities and quality of life.

7. Practical implications

The results of this study may support action across different domains and stakeholder groups.

In research terms, they provide further evidence of the behavioral and psychological impact of harassment in public transport settings. These associations help explain how fear of crime contributes to travel behavior, especially among those exposed either directly or indirectly to harassment.

In transport planning, the findings suggest the need to consider not only direct victims but also bystanders when evaluating the consequences of harassment. Even indirect experiences may result in changes to travel habits, which should be taken into account in system design and service management.

Finally, the study may be relevant for practitioners and policymakers seeking to improve safety for public transport travelers. The results support the development of strategies that reduce perceived insecurity and support regular, comfortable use of the system – especially for women, but also for other groups who may experience similar concerns.

CRediT authorship contribution statement

Useche Sergio: Writing – original draft, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Elisa Alfaro:** Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Conceptualization. **Francisco Alonso:** Supervision, Software, Resources, Funding acquisition, Conceptualization. **Oscar Oviedo-Trespalacios:** Writing – original draft, Validation, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no conflict of interest regarding this manuscript.

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