Women's safety perception before and after the reconstruction of an urban area: A mixed method research

Carlota Jauregui[1], Alexander Trinidad[2], Laura Vozmediano[1]

[1]Department of Social Psychology, University of the Basque Country UPV/EHU (Spain)

[2] Department of Sociology and Social Psychology, University of Cologne (Germany).

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Abstract

This study examines women's perceptions of safety in a high-risk area undergoing urban redesign. Using a mixed-method approach - systematic observation, surveys, and Safety Walks before and after the intervention - it explores how the built environment influences feelings of insecurity. Grounded in Crime Prevention Through Environmental Design (CPTED), the research integrates quantitative and qualitative data to provide a comprehensive understanding of safety. It highlights the often-overlooked issue of women's safety in public spaces and offers insights to guide urban planners and policymakers in creating inclusive, safety-focused design strategies that enhance well-being in public environments.

Keywords: women's safety perception; fear of crime; CPTED; urban transformation; built environment

Correspondence concerning this article should be addressed to Alexander Trinidad.
Email 1: atrinidad@wiso.uni-koeln.de
Email 2: alexander.trinidad@protonmail.com

Introduction

The perception of safety varies significantly across different locations and times, influenced by spatial and temporal factors. This variability is evident in how individuals report their feelings of safety. Research consistently shows that women experience a higher perception of unsafety compared to men, highlighting a critical gender disparity in the perception of security (Glas, et al., 2019; May, et al., 2010;). Consequently, women often feel compelled to restrict and modify their mobility based on specific times and locations (Tandogan & Ilhan, 2016; Trawalter et al., 2022), adopting self-protective measures. These actions can lead to increased psychological distress and a reduced quality of life (Lorenc et al., 2013; Paül i Agustí, et al., 2022; Pearson & Breetzke, 2014).

One could argue that women report feeling more unsafe than men because they experience and notice disorder more frequently. For example, studies have shown that women perceive higher levels of incivility (Johansson & Haandrikman, 2023) and express greater concerns about public space (Gaub, et al., 2021). They are also more likely to report issues such as empty streets and inadequate lighting (Painter, 1996). This suggests that some environments feel safer for women than others, leading to self-protective behaviors such as avoiding certain areas or seeking companionship while walking, even in areas with lower levels of recorded crime (San Juan, Vozmediano & Vergara 2010).

The heightened sense of unsafety among women not only reflects a significant gender inequity but also has profound effects on their daily lives and overall well-being. The need for women to constantly navigate their environment with caution can lead to stress, limiting their opportunities and participation in various social, economic, and recreational activities.

Furthermore, understanding these gendered perceptions of security can inform urban planning and policy-making, aiming to create safer and more inclusive public spaces. By addressing the factors that contribute to perception of unsafety, such as inadequate lighting and public incivility, we can foster environments where all individuals, regardless of gender, feel safe and secure.

This study focuses on the *ad-hoc* evaluation of the transformation of an urban space in the city of Donostia-San Sebastián. Specifically, it examines the change in access from a central neighborhood to a more peripheral one, divided by train tracks. Prior to the change, people had to cross the tracks through an underground tunnel. Subsequently, the state railway infrastructure administration (ADIF) constructed a footbridge for pedestrians to cross from one neighborhood to the other (see Figure 2). The tunnel area had been considered by pedestrians as a critical or risky point, frequently reported as such on the city's citizen participation portal—see the map of the City Council of Donostia–San Sebastián (2020).

The transformation of the space provides a unique opportunity to assess the perceived safety of women who use this space. The general objective of this study is to describe the perception of unsafety of women, and its association with the build and social environment, before and after the transformation of an urban area that was categorized as risky point. As a secondary objective, we explore the feasibility of systematic observation tools (or audits) to capture the urban and social elements that women report as reasons for their perception of unsafety. Therefore, we posit our research questions as follow:

RQ1: What are the differences in the perception of unsafety and associated behaviors among women in a risky area of the city before and after the transformation?

RQ2: To what extent are urban design and social variables associated with women's perception of safety before and after the reconstruction?

RQ3: How do systematic observation tools capture urban design and social characteristics that women identify as elements that increase their unsafety perception?

We must make it clear that this is a descriptive study. Due to methodological limitations (mostly described in the limitations section), the results cannot be interpreted in terms of causal inference and are not generalizable. Therefore, p-values and effect sizes are merely indicative. Despite the potential limitations on the methodology, this study contributes to understanding the perception of unsafety among women in urban environments by examining the transformation of an urban space using mixed method design.

The novelty of this study lies in several key aspects. While previous research using mixed-method approaches to evaluate the environment has employed similar designs (Barker et al., 2023; Ceccato et al., 2024; Iqbal & Ceccato, 2016; Kapoor et al., 2020), this study is the first to apply such a design to a redeveloped urban area. In this context, the quantitative component—surveys and systematic observation—allows for an objective and experiential assessment of the environment, while the qualitative component provides deeper insights into aspects that quantitative methods alone cannot explain. Specifically, it helps explore why certain built environments and security measures contribute more to perceptions of insecurity than others.

Additionally, this study makes a significant contribution to Crime Prevention Through Environmental Design (hereafter CPTED) literature, particularly regarding women's safety—a perspective that remains largely underrepresented in existing research (Barker et al., 2023). By focusing on the transformation of an underground tunnel into a pedestrian footbridge, this study also contributes to the literature on urban design and city planning, particularly in the context of pedestrian crossings over roads or railway lines. Our findings emphasize the importance of

integrating women's safety perspectives into these environments, fostering a more inclusive approach to urban planning (Ceccato et al., 2025).

Literature Background

Women's Safety Perception In The Urban Space

The perception of safety has traditionally been studied within the literature on fear of crime. Fear of crime is a term used to encompass a range of concepts related to the perception of crime, both at the individual and social levels (for a more in-depth discussion, see Gerber et al. 2010; Lee et al., 2020). The individual conceptualization of crime perceptions has been developed around the idea that there are three components: a) affective; b) behavioral; and c) cognitive (Jackson, 2009, 2011; Lee, 2024). In this study, we primarily focus on the cognitive and behavioral components, as the affective aspect is more challenging to capture (for a thorough review, see Lee, 2024). Specifically, we examine the perception of (un)safety and the associated behaviors, i.e., self-protective and avoidance behaviors.

Safety perception refers to a subjective assessment of how safe individuals feel, whereas security perception pertains to an evaluation of objective security measures. For example, factors such as poor lighting or inadequate maintenance of public spaces influence security perception (Chen et al., 2024). Despite the subtle distinction between these concepts, they are highly interrelated, and in practice, their measurement may capture the same phenomena. As a result, much of the literature has treated them as synonymous.

Research has consistently shown a strong link between people's perception of safety and their immediate surroundings, including both urban design and social environments (Chataway & Hart, 2019; Kronkvist & Engström, 2020; Skarlatidou, et al., 2023). Physical and social disorder, in particular, have been found to heighten feelings of unsafety (Hodgkinson & Lunney,

2021; Lee, Boateng, Kim, & Maher, 2022; Winter, Johnson, & Obara, 2021). Particularly, studies indicate that women tend to express greater concern about safety in the presence of such disorder compared to men (Collins, 2016).

Building on this, specific physical and social characteristics of spaces—such as poor lighting, areas allowing concealment or entrapment, poor maintenance, signs of disorder like drug use, perceptions of criminal activity, and weak social cohesion—play a key role in shaping women's fear of crime (Blobaum & Hunecke, 2005; Grohe, 2011; Johansson & Haandrikman, 2023; Koskela & Pain, 2000). These environmental and social factors lead women to classify spaces as either "safe" or "unsafe," contributing to certain areas developing bad reputations (Koskela & Pain, 2000). It has been shown that women adopt more self-protective behaviors than men, such as avoiding certain public spaces—especially at night—or altering their clothing choices to feel safer (Pain, 1997; Tandogan & Ilhan, 2016; Woolnough, 2009). Labeling public spaces or specific times as "dangerous" results in heightened surveillance and restricted use of the space (Ceccato & Loukaitou-Sideris, 2022), ultimately affecting women's mobility and well-being.

Theoretically women concern about safeness stem from multiple sources, including the information women receive during their formative years about the risks present in public spaces (Morrell, 1998; Pryor, et al., 2024). The social learning theory and related frameworks offer possible explanations for this report pattern (van Eijk, 2017). From an early age, boys and girls receive different messages about safety, especially regarding the risk of sexual violence. Parents tend to express their concerns differently depending on the child's gender (Vozmediano et al., 2017). For example, girls, in particular, are often given behavioral guidelines, such as recommendations on how to dress appropriately or warnings about places and times to avoid.

These messages, reinforced by existing gender norms, lead women to internalize a heightened sense of vulnerability, which may manifest later in life (Pryor et al., 2024).

The perception of safety patterns by women has often been treated as the victimization-paradox, and treating women concerns as irrational. The paradox stem in the idea that women report higher unsafety perception despite of being less victims of crime. However, this paradox is an oversimplification of the phenomena that leaves out many alternative explanations (Koeber, 2018, pp. 23-24). For instance, the idea that women's perception of unsafety could be an extension of the fear of becoming a victim of sexual aggression (Ferraro, 1996; Mellgren & Ivert, 2019). Additionally, the paradox fails to account for underreported crimes against women (Randa & Mitchell, 2018), and the potentially underreported perception of safety among men, whose responses may be shaped by gendered socialization processes (Sutton & Farrall, 2005). Moreover, it overlooks the role of intersectionality in victimization surveys (Ascherio, 2023) and fear of crime, which often is diluted in studies that analyze the gender gap without considering other social identities (Ascherio, 2023).

Context Dependency and Environmental Design

Perceptions of safety are not fixed; they vary across different times and places and are significantly shaped by the physical and social characteristics of the surrounding environment. Crime Prevention Through Environmental Design approach suggests that thoughtful urban design can help reduce crime and enhance perceptions of safety (or unsafety).

CPTED approach has evolved over time, adapting to the complexities of urban environments. First-generation CPTED strategies focus primarily on crime prevention through seven core principles: territoriality, surveillance, image management, access control, activity support, target hardening, and geographical juxtaposition (Cozens, et al., 2005). However,

second- generation CPTED goes beyond physical design and focuses on social processes and community participation (Cozens & Love 2015) introducing four new key concepts: social cohesion, community connectivity, community culture, and threshold capacity. Translating principles into interdisciplinary local practice is always complex; at the European level, the Technical Report on Prevention of crime by Urban planning by the European Committee for Standardization and the Handbook "Planning urban design and management for crime prevention" (2007) propose strategies at three levels (planning, design and management) for environmental crime prevention actions to be carried out.

Nowadays, proposals for a third-generation CPTED approaches expand on these principles by incorporating the concept of livability, emphasizing pro-social activities within neighborhoods (Mihinjac & Saville, 2019). This shift highlights the democratization of public spaces, aiming to improve not only urban design but also public health—particularly psychological well-being—and sustainability across economic, environmental, and social dimensions (Armitage & Gamman, 2009; Mihinjac & Saville, 2019).

While CPTED strategies are widely used, their impact on perceptions of safety remains debated. First-generation approaches primarily aim to deter crime, whereas second- and third-generation CPTED also consider how people feel about their safety (Cozens & Love, 2015; DeKeseredy et al., 2009; Gibson, 2016; Mihinjac & Saville, 2019). Some studies suggest that CPTED measures can reduce fear of crime (De Biasi, 2017; Minnery & Lim, 2005), while others find no clear evidence of this effect (Hedayati Marzbali et al., 2012). A key source of uncertainty is the distinction between security perception and safety perception—terms often used interchangeably but with different implications. For example, security measures such as CCTV

cameras and fences may enhance a sense of protection but can also induce fear, making people feel they are entering a high-risk area that requires strict control.

Despite the evolution of CPTED towards a more inclusive and community-centered approach, its effectiveness in addressing women's safety concerns remains limited. Women's perceptions of CPTED strategies are closely tied to how well these strategies respond to their specific experiences and fears. Research shows that women consistently report higher levels of perceived unsafety, even in environments that are considered safe under the CPTED criteria (Chen & Hedayati Marzbali, 2024). This discrepancy highlights a critical gap in CPTED's application: its largely universal design often overlooks the gendered dimensions of safety, assuming that strategies effective for the general population will be equally effective for women.

Thus, there is a growing demand for CPTED strategies that explicitly incorporate gender-responsive measures, recognizing that women's perceptions of safety are shaped by different lived experiences compared to men (Barker et al., 2023). A more tailored approach would involve integrating feminist urban planning principles, including participatory design processes where women contribute to identifying safety issues and co-developing solutions. By shifting from a one-size-fits-all framework to a more intersectional and inclusive model, CPTED can move beyond general crime prevention to create truly safe and equitable urban spaces for all.

Measuring (Un)Safety Perceptions

How perceptions of safety are measured is one of the most frequently discussed topics in criminological literature. Periodically, literature reviews emerge criticizing the inadequate measurement of fear of crime and the broad range of concepts grouped under this term (personal communication, Solymosi, April 12, 2024, Fear of Crime Network Meeting). However, little progress has been made in addressing these concerns.

Survey-based studies often rely on questions that reflect attitudes toward crime or broader social insecurities projected onto crime, rather than directly capturing the experience of feeling unsafe (Natter, 2024). This issue arises from the decontextualization of survey questions—even when respondents are asked about feelings of insecurity in their neighborhood, as done in the European Social Survey (ESS), their answers are elicited outside the actual situation in which they might feel unsafe.

To mitigate this issue, researchers have proposed intensive longitudinal studies that aim to capture perceptions of safety in a more context-specific manner (Engstrom & Kronkvist, 2021; Solymosi et al., 2021). While these studies can track temporal and spatial variations in perceived safety (Engstrom & Kronkvist, 2021; Solymosi et al., 2021), capturing real-time responses within a given context remains challenging. First, there is no precise control over responses. Even if participants' locations can be tracked, if they do not respond at the exact moment they experience a situation, it becomes difficult to capture the context accurately. Second, some studies allow for a certain time lag between the experience and the response. While this approach is more temporally aligned than traditional survey questions, it still fails to fully capture the exact context in which the experience occurred. Additionally, these approaches face high attrition rates, further complicating their effectiveness in measuring safety perceptions.

The CPTED perspective offers researchers a framework to develop tools that partially address this complexity, such as audits to assess the built and social landscape (Ceccato, 2019; Cozens, Babb, & Stefani, 2022; Senna et al., 2025). Despite the well-known limitations of those tools and methods, such as observer bias (Hoeben, et al., 2018) or the cross-sectional nature of the method (Cozens et al., 2022), these limitations are not insurmountable. These tools can be effective as first step to capture environmental indicators that could explain contextual variation

of perceived unsafety. In combination with other data sources or methods, such as secondary spatial data, or semi-structured interviews, as shown in previous research (Ceccato, 2019), those tools can provide valuable information to capture the situation when the perceived unsafety is given.

Method

Study Setting

The study focuses on Donostia - San Sebastián, a city with a population of approximately 187,849, of which 53% are women (INE, 2022). Despite its growth, Donostia - San Sebastián boasts the lowest crime rate in the Basque Country among municipalities with more than 50,000 inhabitants–see Basque police data for 2021-2022 (Ertzaintza – Department of Security of the Basque Government, 2023). The study's setting is a risky point1 regarding the perception of security based on citizens' reports. Specifically, it involves a pedestrian-only underground passageway that connects the city center with a neighborhood.

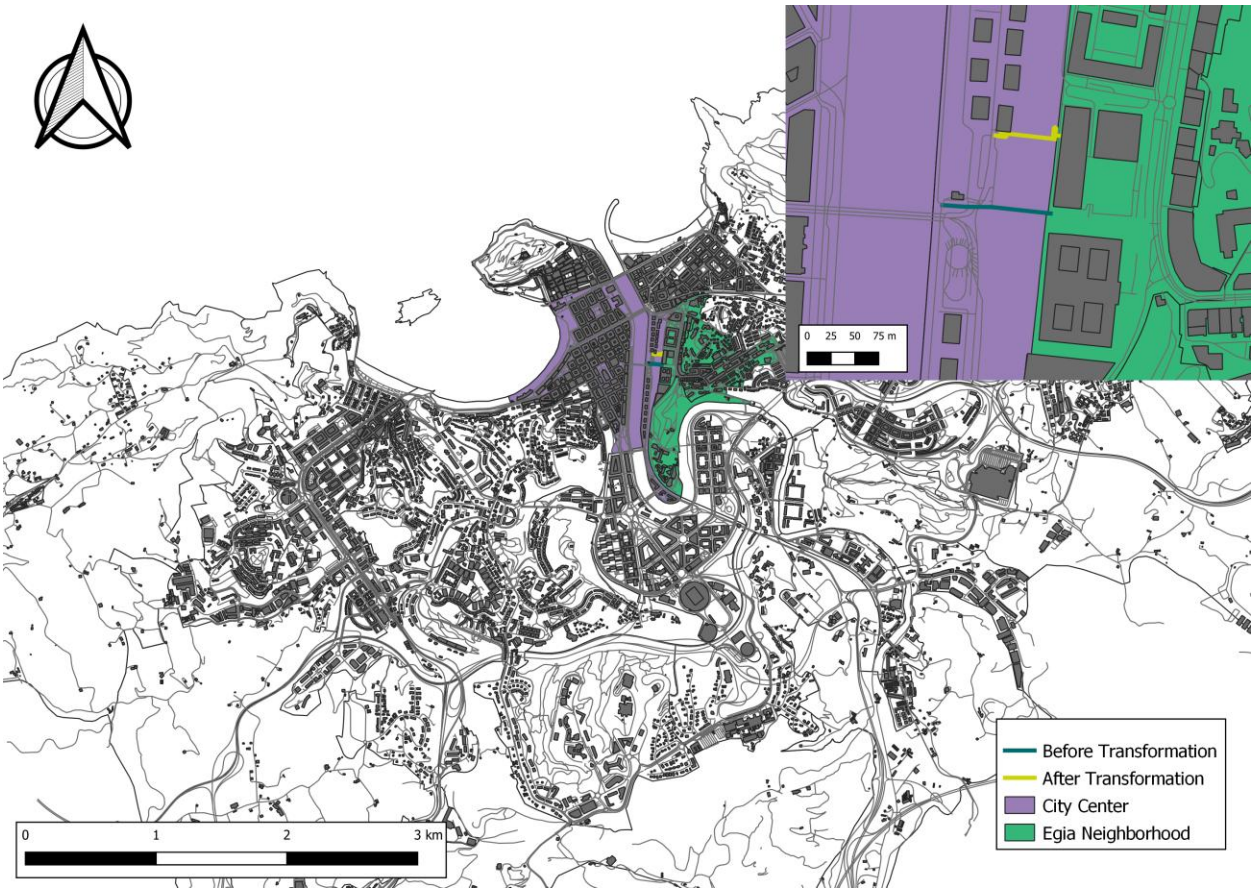
The passageway is located at the underground access to the main bus station, with the main train station situated above it (see Figure 2A). The passageway was planned to be closed (pre-transformation), with pedestrian traffic redirected to an elevated footbridge (post-transformation) that spans the railway tracks from one neighborhood to the other.

Design, Instruments and Sample

To address the research questions, we employed a mixed-methods design, combining quantitative and qualitative methods. For research questions RQ1 and RQ2, we used ad-hoc surveys within the CPTED framework, as well as a safety walk (for more details, see the qualitative section below). To answer RQ3 (and RQ2), we utilized an audit-type tool for

systematic observation, developed based on similar existing tools (Iqbal, & Ceccato, 2016; San Juan, Vozmediano, & Martín, 2019).

Figure 1. Map of the study area.



The entire procedure in both stages obtained a favorable report from the Ethics Committee for Research Involving Human Subjects (CEISH) of the UPV/EHU.

Quantitative Measures

To capture women's perceptions of security and the associated environmental variables (RQ1 and RQ2), we designed an ad hoc survey (see S1 in supplementary materials in OSF under the file tab –link in the references). This survey was administered to women who were using the study setting. The items collected information on their perceptions of crime, personal use of the

setting, and their views on the built environment and social landscape (see supplementary material).

To measure the built environment and social characteristic of both stages (before and after) according to the CPTED framework we used the SUE tool (Safe Urban Environment, Vozmediano, et al., 2024; see S2). A tool designed to assess the aspects that may increase the unsafety or safety perception. It consists of 58 items divided in 8 categories: Criminogenic Design (15 items), Ethnic heterogeneity (6 items), Maintenance (4 items), Miscellaneous (4 items), Physical disorder (7 items), Proactivity (9 items), Security elements (7 items) and Physical disorder (6 items). All items were measured on a scale of 0 to 3 except for Social Disorder, which was analyzed by the presence or absence of the characteristics. We divided the setting of study into three subareas: the middle point of the passageway (see in Figure 2A the marked zone 2) or footbridge (see in Figure 2B the marked zone 2) and the two areas around the entrances (see in Figure 2 A and B the marked zones 1 and 3) of the passageway and footbridge.

Then two independents observers during the day and at night evaluated the setting. For addressing potential observer bias (Observer Bias | Catalog of Bias, n.d.), statistical methods assess the consistency of observations and help determine the extent to which both observers interpret the same environmental factors similarly. In this study, we calculated Cohen's Kappa (1960), which is particularly useful for evaluating agreement beyond chance and ensuring the reliability of observational data (Hallgren, 2012). The Kappa values ranged from .727 to 1, indicating a high level of inter-observer agreement. Disagreements between observers were addressed in team meetings, with a third member of the research team mediating when necessary.

Qualitative Methodology

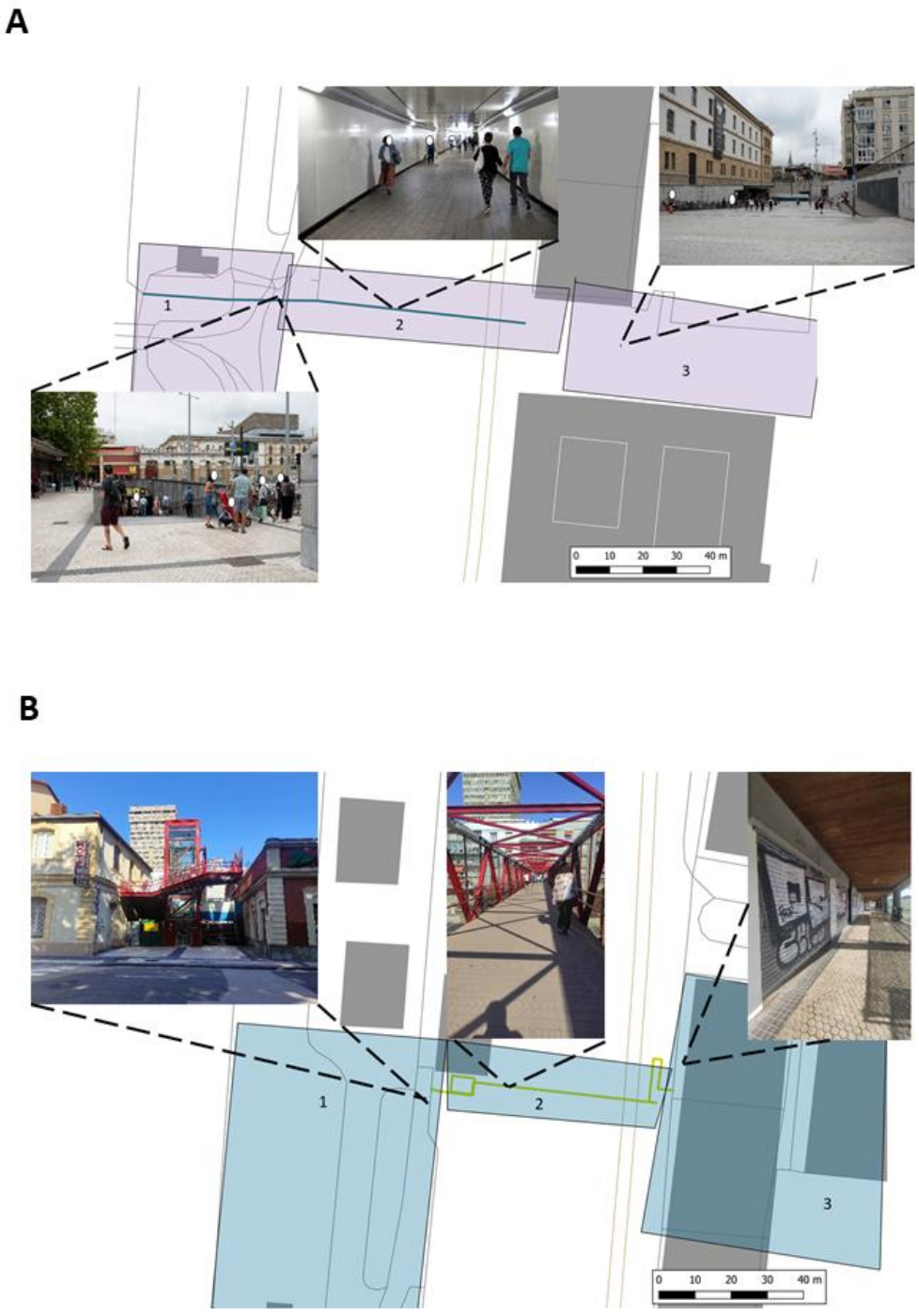
To obtain a more comprehensive understanding of women's perceptions of unsafety (see the review of Cozens, 2022) we complemented the quantitative data with a qualitative measure. Specifically, we conducted Safety Walks (see S3), also known as safety audits, which is a participatory approach involving community members to identify urban issues.

Following previous practices (Mitra & Bardhan, 2017), we conducted two safety walks (one before and one after the transformation) with different women in the study area. The activity involves walking through various parts of the study area and asking open-ended questions about perceived security, built environment variables, and social activities and groups. The conversations were recorded for later transcription and thematic analysis by two members of the research team independently. This approach aimed to identify physical and social characteristics that were not captured by the survey or systematic observation. To assess researcher agreement when coding the themes, we calculated Cohen's Kappa, which ranged from .45 to .88. Disagreements were addressed in team meetings.

An Integrative Perspective: Triangulation Data

The mixed-methods approach was chosen to provide a comprehensive understanding of women's safety perceptions in both pre- and post-transformation scenarios. Surveys allow us to quantify the average perception of safety from a reduce women sample and identify some potential their reasons for feeling unsafe. They are useful for standardization and capturing well-defined theoretical constructs. However, surveys are constrained by predefined questions, which can limit their ability to capture the complexity of safety perceptions.

Figure 2. Setting before (A) and after (B) the transformation divided in three subzones



This is particularly relevant in cases where sampling limitations exist (as in this study) or when the constructs being measured are difficult to define or easily misinterpreted. Systematic observation tools, such as CPTEDs audits, assist in objectively assessing security principles within the built environment from a research perspective. However, it is important to recognize that these methods can still be influenced by biases and have often overlooked a gender perspective, failing to address the specific safety concerns and experiences of different genders—though some exceptions exist.

To address these limitations, safety walks offer a deeper, more contextualized understanding of why certain environments feel safer than others. They help explain apparent improvements or deteriorations in safety perception, capture user experiences, and highlight gaps between systematic assessments and lived realities. By triangulating data from surveys, systematic observations, and safety walks, the study strengthens its findings while also identifying methodological gaps across different approaches. This integration ensures a more robust and nuanced understanding of safety perceptions and environmental changes.

Procedure and Sample

Survey

The survey sample was based on a convenience sample of women walking around the study setting (Figures 1 and 2), with surveys conducted until the predetermined number was reached. The sample consisted of 100 women (50 in each stage). The number of participants was decided based on time and budget constraints. All participants were over 18 years old. Before the transformation, the largest age group was women aged 26-45 (50%), while after the transformation, the largest group was women aged 46-65 (46%). In both stages, the least represented group was women aged 18-25 (26% before, 8% after). All participants were city

residents, with most living in peripheral neighborhoods (51%) and a smaller percentage from central neighborhoods (22%).

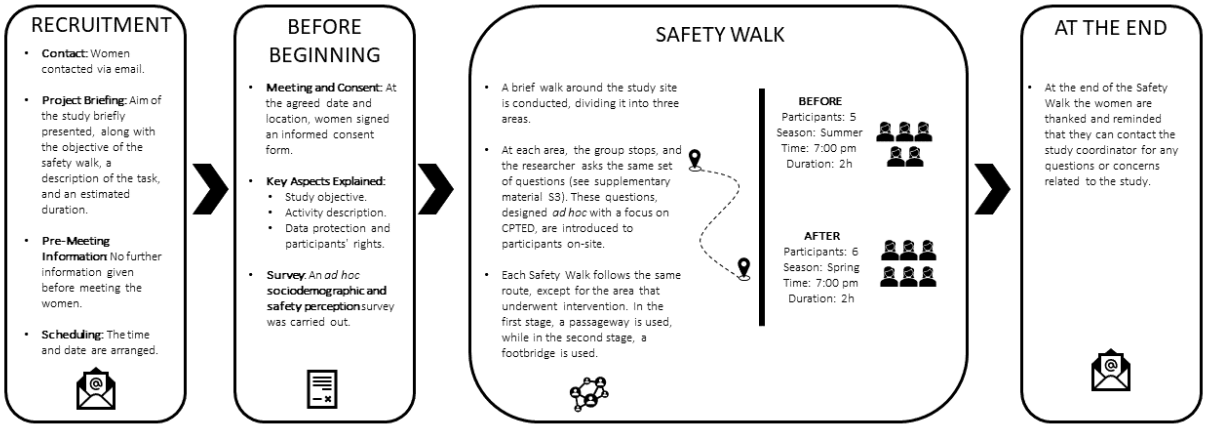
Regarding the use of the area, most women used it almost daily (40%) or once or twice a week (30%), predominantly during the day (60%), and the rest used the setting both day and night (40%). No women in our sample used the area exclusively at night. Additionally, a large group of women used the setting both alone and accompanied (47%), followed by those who usually used it alone (42%), and to a lesser extent, those who used it only when accompanied (11%).

Safety Walk

A total of 11 women (5 in the first stage and 6 in the second stage) participated in the study, recruited through the snowball sampling method. The number of participants was decided based on time and budget limitations. Regarding time constraints, the study was limited by the imminent closure of the train station tunnel, as informed by the local municipality. As for budget constraints, funding was only available to hire the facilitator for the Safety Walk, but not to provide incentives for participants. Offering incentives could have increased participation and enriched the study's findings. All participants were over 18 years old and residents of the city. Previous research suggests using small samples to ensure that all participants can easily participate, stay together during the activity, and have their voices heard (Bhatla et al., 2013; United Nations Women Asia and the Pacific, 2021; Women in Cities International, 2008). These activities benefit from a manageable and intimate group, facilitating more specific and meaningful dialogues. We acknowledge the study's limitations in this regard. While the objective is not to achieve representativeness, we recognize that qualitative methods provide in-depth insights into women's lived experiences. The insights from the Safety Walk are crucial for

interpreting and contextualizing the findings obtained through quantitative measures. Thus, while the sample size is limited, the depth and contextual relevance of the data contribute meaningfully to the study's objectives and to the broader discourse on gender-inclusive urban safety. The Safety walk protocol is included in the supplementary materials and the process explained in the Figure 3.

Figure 3. Infographic illustrating the Safety Walk process.



Data Analysis

First, we conducted univariate analyses for the socio-demographic variables, those related to the perception of unsafety and those related to the participants' use of the space under study. Second, we conducted bivariate analyses between the two stages. We use the chi-square (χ^2) test and report the Phi coefficient (Φ) or Cramer's V as the effect size of the difference between before and after the transformation. Third, to analyze the systematic observation data, we calculated the mean punctuation for all the three subareas for each stage. Table S4 in the

supplementary material shows the range of punctuations for each scale and the rescaling value from 0-100. We then obtained the relative change (*C*) considering the rescale punctuation (0-100) to compare the before and after built environment and social activity characteristics of the settings:

$$C = \frac{\textbf{\textit{Rescaled After value} − \textit{Rescaled Before value}}}{\textbf{\textit{Rescaled Before value}}} * 100$$

We also use some visualizations to show the relative changes. Finally, we conducted a thematic analysis to analyze the Safety Walk.

Results

Results Of The Surveys On Women's Perception Of Unsafety

The characteristics of women's perceptions of unsafety are summarized in Table 1. The majority of women in our sample (61%) reported perceiving unsafety at some moment in the area under study. However, the proportion of reported unsafety was higher in the setting before the transformation (63.9%) than in the setting after the transformation to after (36.1%), (Φ = .33; 95 % CI [0.11 – 0.54]).

We also compared the frequency of the perception of unsafety and the perception of unsafety per type of crime between the women who reported unsafety perception (see Table 1). However, none of the comparisons have an effect size different from zero.

We asked the women who reported perceiving unsafety (n = 61) about the potential reasons (Tables 2 and 3) for their perception. When considering the CPTED themes for those reasons (Table 2), the majority pointed to the *activity in the area* (n = 49), the *design* (n = 55), and the *type of people* (n = 47).

Table 1. Survey Results on Unsafety perception before and after Comparisons

Item		Before n (%)	After n (%)	χ^2	*Df*	*p*-value	Φ/V	95 % CI
Unsafety Perception				10.76	1	.001	.33	[0.11, 0.54]
	No	11 (28.2%)	28 (71.8%)					
	Yes	39 (63.9%)	22 (36.1%)					
Frequency of Unsafety				8.481	3	.030	.30	[0.00, 0.55]
	Never	11 (28.2%)	28 (71.8%)					
	Very Rarely	7 (58.3%)	5 (41.7%)					
	Sometimes in the Last Month	22 (64.7%)	12 (35.3%)					
	Every Week	2 (28.6%)	5 (71.4%)					
	Practically Daily	8 (100 %)	0 (0%)					
Unsafety Perception Per Type of Crime								
Robbery				0.196	1	.658	0	[0.00, 0.32]
	No	9 (56.2%)	7 (43.8%)					
	Yes	30 (66.7%)	15 (33.3%)					
Physical Aggression				2.406	1	.121	.19	[0.00, 0.47]
	No	19 (54.3%)	16 (45.7%)					
	Yes	20 (76.9%)	6 (23.1%)					
Sexual Aggression				0.012	1	.910	0	[0.00, 0.26]
	No	14 (60.9%)	9 (39.1%)					
	Yes	25 (65.8%)	13 (34.2%)					
Harassment				0.224	1	.636	0	[0.00, 0.32]
	No	21 (60.0%)	14 (40.0%)					
	Yes	18 (69.2%)	8 (30.8%)					

However, only the *activity in the area* and the *type of people* in the area shown differences between the setting before and after the transformation. Specifically, more women cited the *activity in the area* as a reason for their unsafety in the setting before the transformation compared to after (Φ = .47; 95 % CI [0.20 – 0.73]). The other CPTED themes –*type of people,*

commercial activity, *unstructured activities* (95 % CI contained 0), *design, lack of police, maintenance or public transport access*– did not show statistically significant differences.

Table 2. Results of the Surveys. Reasons for the Unsafety (based on the CPTED approach) among stages

Item		**Before n (%)**	**After n (%)**	χ^2	***p-value***	**Φ**	**95 % CI**
Activity in The Area				12.035	< .001	.47	[0.20, 0.73]
	No	2 (16.7%)	10 (83.3%)				
	Yes	37 (75.5%)	12 (24.5%)				
Commercial Activity				2.375	.091	.19	[0.00, 0.47]
	No	23 (56.1%)	18 (43.9%)				
	Yes	16 (80.0%)	4 (20.0%)				
Unstructured Activities				4.262	.020	.28	[0.00, 0.55]
	No	30 (57.7%)	22 (42.3%)				
	Yes	9 (100.0%)	0 (0.0%)				
Design				0.353	.404	.03	[0.00, 0.36]
	No	5 (83.3%)	1 (16.7%)				
	Yes	34 (61.8%)	21 (38.2%)				
Lack of Police				0	1	-	
	No	38 (63.3%)	22 (36.7%)				
	Yes	1 (100.0%)	0 (0.0%)				
Maintenance				0.889	.262	.11	[0.00, 0.40]
	No	35 (67.3%)	17 (32.7%)				
	Yes	4 (44.4%)	5 (55.6%)				
Public Transport				0.087	.645	0	[0.00, 0.33]
	No	35 (62.5%)	21 (37.5%)				
	Yes	4 (80 %)	1 (20 %)				
Type of People				7.965	.003	.38	[0.08, 0.64]
	No	4 (28.6%)	10 (71.4%)				
	Yes	35 (74.5%)	12 (25.5%)				

Women who reported to perceive unsafety were asked about previous victimization experiences. Few of those (n = 6) had been victims of a crime recently, mostly robbery (n = 3). Likewise, some of the women (n = 13) knew of someone who was recently the victim of a crime. Again, mostly robbery (n = 8) followed by sexual aggression (n = 4). However, we did not find any the differences between the settings before and after the transformation (see Table 3).

Self-Protective Behaviors

In terms of self-protective behaviors, it was found that of the women who reported having felt unsafe at some point (n = 61), 41% (n = 25) reported having performed self-protective behaviors. These women reported engaging in protective behaviors (e.g. calling someone by telephone). If we look at the differences between setting (before and after), we observe that there is a decrease in the number of women who reported engaging in self-protective behaviors (Before: 25%; After: 16%). Although the differences between stages were not statistically significant in any case.

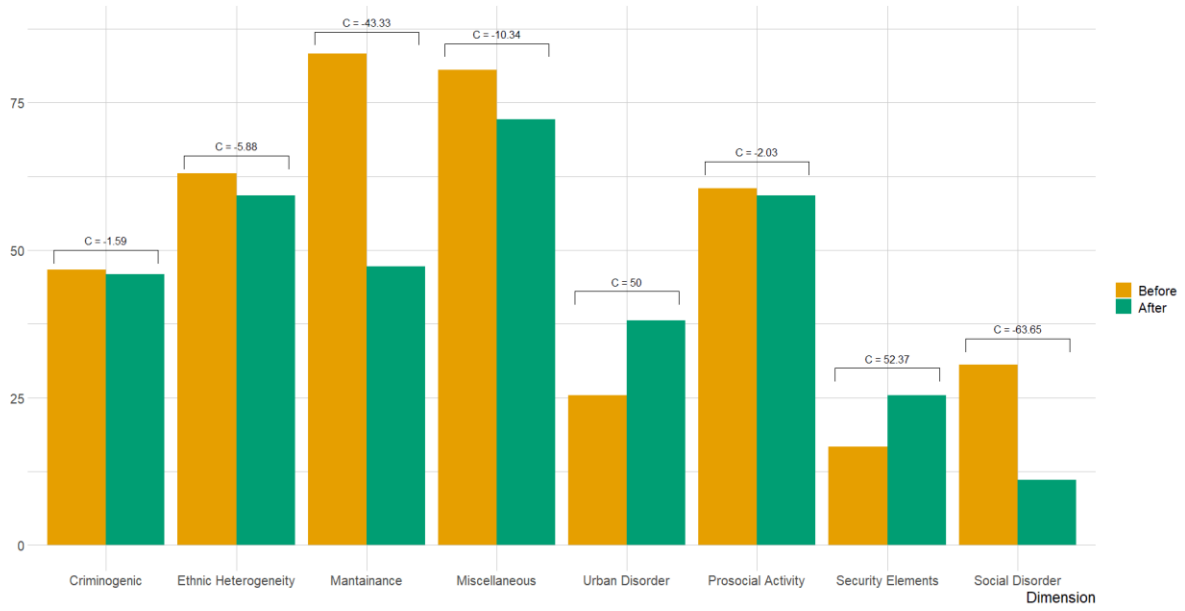
When looking at avoidance behaviors, of the total number of participants who reported perceiving unsafety, 66% (n = 40) reported engaging in avoidance behavior. However, the differences between stages were not statistically significant in any case.

Built and Social Environment: Systematic Social Observation

The results of the systematic social observation reveal some changes in the physical and social characteristics of the setting after the modification. Figure 4 presents the rescaled sum of scores for each characteristic assessed using the SUE tool (Vozmediano, et al., in press) before and after the intervention. Improvements are evident in several key aspects, including *proactivity in the area* (relative change of -2.03 %), *social disorder* (relative change of -63.65 %) and, *security elements* (relative change of 52.37 %). These changes indicate a setting with increased activity support, meaning more people engaging in social activities such as sports or leisure. Conversely, there is a decline in disruptive behaviors, such as drinking alcohol in public spaces or potential altercations. Additionally, security features, such as police presence and CCTV surveillance, have increased, further contributing to a safer environment.

On the contrary, some aspects have worsened, including *physical disorder* (with a relative change of 50%) and *maintenance* (relative change of -43.33%). Additionally, there is a slight deterioration in *criminogenic characteristics* (relative change of -1.59%). In other words, the space is perceived as more criminogenic, primarily due to its physical attributes. This includes a stronger sense that the public space is neglected, with signs such as closed or abandoned premises, poorly maintained streets and vegetation, and a design that creates opportunities for offenders to escape easily.

Figure 4. Sum of the Scores of SUE tool and Relative Change Before and After the Urban Transformation.



Results Of The Safety Walks Conducted With Women

We will now present the most notable findings from the thematic analysis of the Safety Walk. Consistent with the survey results, all women who participated in the Safety Walk reported feeling unsafe at some point in the area during both stages. Overall, the area under study

was perceived as unpleasant. This perception was particularly strong at night, when the lack of social activity and insufficient lighting heightened the sense of unsafety.

When asked about the factors influencing their perception of unsafety, *urban design* was the most frequently mentioned reason. Before the transformation, all women indicated that the urban design contributed to their feelings of unsafety (see more in supplementary material S5). This percentage decreased in some areas after the transformation, dropping from 100% to 67% in zones 1 and 3.

In relation to urban design, most women expressed concerns about unsafety due to insufficient *lighting* in zones 1 and 3, both before and after the transformation. However, only half of the women mentioned concerns about lighting in zone 3 after the transformation. Notably, none of the women reported a lack of lighting in the walkway areas (zones 2) before or after the transformation (see Figure 2 for example of the settings).

The lack of *commercial activity* was also identified as a reason for perception of unsafety in zones 1 and 2, both before and after the transformation, but not in zone 3. Regarding the *type of people* in the area, fewer women reported this as an issue in zone 3 after the transformation. Similarly, fewer women reported issues with security features, such as the lack of *CCTVs* (e.g., in zone 1, 40% before and 0% after) and *police presence* (e.g., in zone 3, 60% before and 0% after). On the other hand, there was a noted decline in the *maintenance of the area*, consistent with the survey findings.

There was significant concern at all stages regarding the criminogenic characteristics of the entire area. Specifically, all participants noted a *lack of visibility*, which hindered the ability of others to witness if something were to happen to anyone. Concerning the possibilities for

offenders to escape, all participants agreed (both before and after the transformation) that the design provided escape opportunities for potential offenders.

Regarding escape options for potential victims, the proportion of women who identified potential escape routes in zones 2 and 3 (both before and after the transformation) was low. Only in zone 1 did women report the existence of more escape options for potential victims (before: all participants; after: four women). In terms of the temporal use of the area, most participants in both settings (except in zone 3 before and after the transformation) indicated they would use the area during the day but not at night.

Finally, in terms of *self-protective behaviors*, all participants in both settings stated they would consider a self-protective measure. The number of women who agreed to consider *self-defense* measures increased in zones 1 and 2 after the transformation. Regarding *altruistic fear*, or concern for the safety of someone they knew, all women in zone 1 expressed concern. In zone 2, more women were concerned after the transformation, whereas in zone 3, only three women before and two women after the transformation expressed concern.

Discussion

In this study, we examined whether there were differences in the perception of unsafety and associated behaviors among women before and after the reconstruction of an urban area considered risky (RQ1). Our bivariate analysis results indicate a significant difference between the women surveyed in the tunnel (before reconstruction) and those on the walkway (after reconstruction). These findings align with research on urban design, visibility, social disorder, the locality of underground stations, and their association with crime (Ceccato et al. 2013) and the perception of safety (Ceccato et al. 2024).

Table 3. Survey Results of Victimization Experiences (Previous and Vicarious) Before and After Comparisons

Items		**Before n (%)**	**After n (%)**	χ^2	*Df*	*p-Value*	**Φ**	**95 % CI**
Prev. Victimization				4.375	1	.019	.30	[0.00, 0.56]
	No	38 (69.1%)	17 (30.9%)					
	Yes	1 (16.7 %)	5 (83.3%)					
Prev. Victimization Robbery				2.96	1	.045	.27	[0.00, 0.54]
	No	38 (66.7%)	19 (33.3%)					
	Yes	0 (0%)	3 (100%)					
Prev. Victimization Physical Aggression				0	1	1	0	[0.00, 0.32]
	No	38 (63.3%)	22 (36.7%)					
	Yes	1 (100%)	0 (0.%)					
Prev. Victimization Sexual Aggression				0.078	1	.367	.11	[0.00, 0.40]
	No	38 (64.4%)	21 (35.6%)					
	Yes	0 (0.%)	1 (100%)					
Prev. Victimization Harassment				0.078	1	. 367	.11	[0.00, 0.40]
	No	38 (64.4%)	21 (35.6%)					
	Yes	0 (0%)	1 (100.%)					
Vicarious Victimization				6.159	1	.008	.34	[0.00, 0.60]
	No	35 (72.9%)	13 (27.1%)					
	Yes	4 (30.8%)	9 (69.2%)					
Vicarious Victimization Robbery				1.627	1	.124	.17	[0.00, 0.45]
	No	36 (67.9%)	17 (32.1%)					
	Yes	3 (37.5%)	5 (62.5%)					
Vicarious Victimization Physical Aggression				4.737	1	.0295	-	-
	No	39 (63.9%)	22 (36.1%)					
	Yes	0 (0%)	0 (0%)					
Vicarious Victimization Sexual Aggression				4.911	1	.014	.33	[0.00, 0.59]
	No	39 (68.4%)	18 (31.6%)					
	Yes	0 (0%)	4 (6.6%)					
Vicarious Victimization Harassment				0	1	1	0	[0.00, 0.32]
	No	38 (63.3%)	22 (36.7%)					
	Yes	1 (100%)	0 (0%)					

Additionally, regarding individual variables such as protective behaviors and previous victimization, the results showed no differences between the two locations. While most women used protective measures, consistent with existing evidence, these behaviors did not change before or after the space transformation. This could be explained by the fact that such behaviors are deeply ingrained in women, and changing certain urban environment elements is unlikely to alter these possibly crystallized habits (Woolnough, 2009).

We also investigated whether systematic observation tools based on CPTED criteria, such as the SUE, captured the urban design and social environment elements that women perceived as contributing to insecurity (RQ3). Generally, the answer is affirmative. While many CPTED criteria differences are similar in both scenarios, some systematically observed criteria in our study reflect what women reported in the surveys and Safety Walks, consistent with other empirical studies (see Cozens, 2022). For example, improvements in security elements, area activity, and social disorder, along with deteriorations in maintenance, physical disorder, and criminogenic features of the space, were noted. However, this concordance may be due to the fact that the systematic observation were women, as research shows that women generally perceive and report social and physical disorder more frequently than men (Johansson & Haandrikman, 2023).

Finally, we also asked the extent to which urban and social design are related to the perception of insecurity (RQ2). The transformation from an underground space to an elevated area with improved visibility, as implemented in the study area, may partially explain the change in women's perception of safety, as reflected in the survey data. The perception of increased unsafety in spaces with limited visibility, higher social disorder, or a lack of elements that promote informal surveillance is well-documented in CPTED literature (Ceccato et al., 2024).

Our systematic observation measure also supports this idea. While the survey and Safety Walk did not indicate significant differences between spaces, the level of activity in the area—which increased compared to the pre-transformation phase—was the only CPTED measure that showed a notable change. An explanation is that the transition from the tunnel to the bridge spans only about 89 meters. Notably, the tunnel's exit or entrance leads directly to the plaza (Zone 3), where groups of friends and visitors from a nearby public center frequently gather, creating a lively atmosphere. In contrast, the immediate vicinity of the bridge has less activity, since it is a low-density residential area with no commercial activity, even finding a café requires walking through covered and unwelcoming spaces (see Figure 2B). Although a nearby residential area with various shops and cafés is typically bustling, which fosters a sense of informal surveillance and contributing to a perception of greater safety.

This study highlights that security measures do not always translate into a greater perception of safety, as reflected in both the quantitative measures –survey responses and systematic observation measures—and qualitative measures—comments from the Safety Walk. For example, while strategies such as hotspot policing may effectively reduce crime, they do not necessarily alleviate feelings of unsafety. Crime prevention strategies, particularly those centered on increased police presence or CCTV systems, do not always lead to an improved sense of safety among the public. While a higher police presence may contribute to a temporary reduction in crime (Weisburd et al., 2022), it does not necessarily enhance collective efficacy or strengthen informal surveillance mechanisms that endure over time and foster a sustained perception of safety (Nakamura & Managi, 2020).

From a gender perspective, this distinction is particularly relevant. Women often assess safety differently than men, considering not only crime rates but also the overall social

environment, escape routes, visibility, and the presence of potential threats. Increased policing may not necessarily address these concerns, as it does not directly alter the built environment or social dynamics that influence women's perceptions of safety. Instead, long-term improvements require strategies that integrate gender-sensitive urban design and technology, promoting well-lit, open, and sustainable environments. Vitality can be enhanced with desirable activities both during day and night, and mixed land uses, thus promoting natural surveillance and a sense of community; avoiding empty areas with no use, reducing incivilities and maintain the spaces is also relevant (Politécnico di Milano 2007). Therefore, designs should encourage active use of spaces, fostering a lasting and sustainable sense of safety—such as through the presence of shop owners, pedestrians, engaged community members, and the use of natural energy sources like solar-powered lighting (Mihinjac & Saville, 2019; Saville & Mihinjac, 2022). Promotion of desirable activities as a strategy for a good level of natural surveillance, as well as a tool for promoting social cohesion is present since first- and second- generation CPTED, and according to our results may be one of the key aspects to be considered in future studies on the relation between design and safety perception with a gender perspective. This reinforces the need for a comprehensive approach to crime prevention that moves beyond enforcement and incorporates inclusive urban planning to create safer spaces for all (Flint Ashery & Natapov, 2021).

Limitations

Although several limitations have already been mentioned throughout the manuscript, additional considerations should be taken into account when interpreting the results. Firstly, an important limitation would be the sample size and sampling method –convenience sample- when carrying out the surveys and the Safety Walk. In the surveys we obtained a sample of 100 women participants and in the Safety Walk, 11. Considering that there are 99060 women living

in the city of Donostia - San Sebastián, the sample of the present study is not representative and, therefore, the results cannot be generalized. Furthermore, by carrying out the study in a residential neighborhood with people who walk through it, we need to point the selection bias introduced into the sample, given that not all ages, ethnicities, socio-economic status, etc. may be represented.

Another key constraint is the use of *ad hoc* instruments in the survey. Although it incorporated previously validated items with good reliability, the survey was specifically designed for this study, which may limit its generalizability and comparability with other research. While this approach allowed for tailored data collection, it lacked a standardized framework that could ensure consistency across different contexts. Future research should develop instruments that integrate a gender perspective, enabling a more accurate capture of women's perceptions of crime and its consequences while improving reliability and facilitating cross-study comparisons.

Another issue to be considered is that both during the surveys and during the Safety Walk (and especially during the Safety Walk) questions were asked about perceptions of unsafety. As mentioned above, for the scientific community itself, it is a phenomenon that is difficult to conceptualize, with different interpretations, measurements, etc. It is conceivable that this may be the case with participants when they are asked how they feel about their safety and when they are asked about other aspects of safety. In other words, we can find a bias in the participants' interpretation of the questions. And, in relation to this problem, there may be a response bias, particularly in activities such as the Safety Walk, where women, together and in person, engage in discussions for a period of time and may respond in a socially accepted way without reflecting their true perceptions.

Finally, regarding the measurement of the physical and social environment, it is worth mentioning that some limitation in the results can be found due to observer bias or even confirmation bias. As Cozens (2022) explains, CPTED audits are essentially subjective and therefore the results may be associated with the values and opinions of the auditors. It should also be borne in mind that such tools present results from a specific time and date and are therefore a snapshot of what is happening in that place. Future studies using systematic observation should account for observers' individual characteristics and carefully design observation measures to minimize potential biases (Hoeben et al., 2018).

In addition to the limitations already identified in our CPTED audit, , our study was not explicitly designed for capturing intersectionality; and we did not account for how factors such as race, ethnicity, class, sexual orientation, or disability shape women's experiences and perceptions of threat differently. This underscores the need for more inclusive tools that integrate both objective CPTED principles and subjective, intersectional perspectives to better understand diverse safety concerns.

Implications for Future Research and Practice

While sample size is undoubtedly limited in terms of generalization, we should consider that samples were composed of women that were using the researched area, therefore being potential representatives of a smaller group: female users of the specific urban area. Size of the population of female users could not be estimated for this study but could be a significant way forward for future studies.

The strength of the contribution lies mainly in the proposed method that allows deeply studying perceptions and behaviors of women, and design and use characteristics urban areas. And it is noteworthy that any improvement aimed for the most vulnerable groups will benefit all

citizens. This proposal could be applied prior to the modification of urban areas, in order to establish priorities by the public, and also for assessing the impact of a particular change, as we did. Therefore, we propose a potentially helpful way of evaluating safety at the micro level, particularly interesting for local councils.

By using and combining the three methodological approaches, the present study has been able to identify which specific characteristics of the urban environment are associated women's perception of security. In this way, with the data obtained, it is possible to make a series of suggestions for the improvement of this space, through the design of specific interventions for this area that can be subsequently evaluated. It should also be noted that this type of study allows the community to be involved in decision-making regarding the safety of their city. In this way, it is possible to think that the community may become more responsible for its spaces, which could lead to an improvement of the area by non-invasive methods and more by the neighborhood's own natural surveillance and would do so through active and cooperative participation with other institutions.

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Author Bio Statements

Carlota Jauregui is a PhD student at the Department of Social Psychology at the University of the Basque Country UPV/EHU. Her research focuses on fear of crime, women's experiences, and urban space. She approaches these issues from a gender perspective, examining how fear of crime can affect women's lives and overall quality of life in urban environments.

Alexander Trinidad is a postdoctoral researcher and lecturer at the Chair of Methods of Empirical Social Research within the Department of Sociology and Social Psychology at the University of Cologne, Germany. His research focuses on the patterns of police-recorded crime across time and space, how people perceive crime and how these perceptions vary across time and place. He is also interested in meta-science and research synthesis methods in the behavioral sciences.

Laura Vozmediano is an Associate Professor in the Department of Social Psychology at the Faculty of Psychology, University of the Basque Country UPV/EHU, where she teaches Psychology and Criminology. Co-principal investigator of a research group on Applied Psychology and Criminology, her research activity focuses on the analysis and promotion of safe and sustainable public urban spaces. From the Environmental Psychology perspective, she addresses the promotion of sustainable and circular behaviors; while from Environmental Criminology, she researches socio environmental influences on safety perceptions, aimed to promote safer cities for all groups of citizens.