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Development and Analysis of a Crowdsourced Safety Map: User Input Study in Barcelona

Master's Thesis (30 ECTS)

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Abstract:

This thesis explores the topic of safety in urban mobility. While safety is at the top of the agenda in most European cities nowadays, in some cases, no decent track is kept on how citizens perceive safety. This is a limitation in introducing efficient and well-targeted urban services. To address this issue, a crowdsourced platform was created where users could indicate spots that either feel nice and welcoming or unsafe and scary. Citizens were involved in the platform's design, which indicated reasons for them to feel safe or unsafe in public spaces. Interviews with women were conducted to understand shortcomings regarding safety in public spaces and their significant fears. The platform was deployed in Barcelona, Spain, through promotion in public spaces and online platforms. The data collection took three weeks, resulting in over a hundred points with safe or unsafe tags. The data was later analyzed using additional Barcelona Open Data Portal information. The main focus of the analyses was how infrastructure influences the feeling of safety. This study proves that safety perception is gender-related but depends on previous experiences and familiarity with the surroundings. The correlation between infrastructure and perception was found to be positive. However, this is primarily due to city-specific factors. This shows that it is particularly challenging for cities to target improvements in safety perception through advancements in urban infrastructure, as safety is very individual and subjective. This master's thesis was conducted in collaboration with Your Way Home, a startup that helps women and queer people move safely around cities. The company will continue the analysis, and the platform will be deployed in more cities to confirm and expand the findings.

Keywords:

safety perception, gender mobility, crowdsourcing, open data, urban infrastructure, correlation matrix, user-driven design

CERCS: P170 Computer science, numerical analysis, systems, control.

Rahvaühendusliku turvakaardistiku arendamine ja analüüs: kasutaja sisendi uuring Barcelonas

Lühikokkuvõte:

See magistritöö uurib teemat turvalisusest linnaliikumises. Kuigi turvalisus on praegu enamiku Euroopa linnade päevakorras esikohal, mõnel juhul pole kodanike turvalisustaju kohta piisavalt head jälgimist. See on piirang tõhusate ja sihitud linnateenuste tutvustamisel. Selle probleemi lahendamiseks loodi rahvaühenduslik platvorm, kus kasutajad saavad näidata kohti, mis tunduvad kas meeldivad ja tervitatavad või ebaturvalised ja hirmutavad. Kodanikud osalesid platvormi kujundamises, mis näitas põhjuseid, miks nad end avalikes kohtades turvaliselt või ebaturvaliselt tunnevad. Intervjuusid naistega viidi läbi turvalisuse puudujääkide mõistmiseks avalikes kohtades ja nende oluliste hirmude mõistmiseks. Platvorm käivitati Barcelonas, Hispaanias, reklaamides seda avalikes kohtades ja

veebiplatvormidel. Andmete kogumine võttis aega kolm nädalat, tulemuseks oli üle saja punkti, millele märgiti turvalised või ebaturvalised sildid. Andmeid analüüsiti hiljem täiendava Barcelonas asuva avatud andmepordi teabe abil. Analüüside peamine fookus oli infrastruktuuri mõju turvatunde osas. See uuring tõestab, et turvalisuse taju on seotud sooga, kuid sõltub varasematest kogemustest ja tutvumisest ümbruskonnaga. Infrastruktuuri ja tajumise vahel leiti positiivne seos. See on aga peamiselt tingitud linnaomastest teguritest. See näitab, et linnadel on eriti keeruline turvatunde parandamisele suunatud linnainfrastruktuuri edusammude kaudu, kuna turvalisus on väga individuaalne ja subjektiivne. See magistritöö tehti koostöös ettevõttega Your Way Home, mis aitab naistel ja queer-inimestel linnades turvaliselt liikuda. Ettevõte jätkab analüüsi ning platvorm käivitatakse rohkemates linnades, et kinnitada ja laiendada leide.[1]

Võtmesõnad:

turvatunde taju, sooline liikuvus, rahvaühenduslik andmekogumine, avatud andmed, linnainfrastruktuur, korrilatsioonimaatriks, kasutajakeskne disain

CERCS: P170 Arvutiteadus, arvutusmeetodid, süsteemid, juhtimine.

[1] The translation comes from a combined effort of the student and ChatGPT (10.05.2024), i.e. a language model whose training is based on a large number of different text sources. ChatGPT is developed by OpenAI. For more information about ChatGPT and OpenAI: https://openai.com. Prompt: “Translate the original Abstract from English to Estonian.”

Contents

1 Introduction

In this chapter, the introduction to the gender perspective in urban mobility is shown. The site of the case study presents relevant information. In the end, the author's contribution to this thesis is discussed with limitations and the scope of this paper.

1.1 General Overview

Safety is one of the most pressing issues in urban mobility. The freedom of moving around in the city significantly contributes to well-being and satisfaction. Risk perception may greatly affect travel behavior and decrease the accessibility of job opportunities or social life. It is vital to understand the gender-related differences in the fear of crime. For women, it is mainly shaped by the fear of sexual victimization [1]. Canadian Women's Foundation [2] has stated that sexual assault is an unwanted sexual activity like kissing or touching without consent or rape. Sexual harassment also involves unwanted comments, behavior, and sexual contact. The victims of sexual violence suffer long-lasting, widespread consequences [3] that go beyond the limitations of transportation options.

However, this paper focuses on gathering information about the fear anonymously and directly from the potential victims. Through interviews with women, the main fear factors are established. This study will deepen the understanding of possible improvements in the public space, and some actions will be undertaken. This master thesis was performed in collaboration with the Barcelona Metropolitan Area, which pinpoints that the region does not collect data on public spaces' safety perceptions based on gender. This problem prevents them from taking laser-focused actions to improve the situation.

Another common problem observed in the cities is that even if the police gather the information, it is kept from other departments. Your Way Home, the startup working with women and queer people towards enhanced safety, aims to build sustainable, long-lasting workflows that can help public entities manage the information about safety perception in the city. It will also help them allocate resources to the citizens' most pressing issues. Through comprehensive privacy policies, Your Way Home is ambitious to share the information gathered through the platform with public and private bodies with the resources to improve the current situation. This study is building on Your Way Home's work as a business partner for this thesis.

1.2 Background and Context

Barcelona was chosen as a case study as this is where most crimes happen in Spain [4]. There is an ongoing discussion about safety, and the city keeps track of the perception of safety. The Victimization Surveys have been conducted for almost forty years and have delivered information about crimes, victims, and safety perception over this period. However, the publications need more in-depth analysis and spatial correlations concerning neighborhoods. The platform developed under this study could complement the survey with the most up-to-date information and few resources.

In this chapter, the city of Barcelona is presented with its most relevant statistics on safety. The situation regarding gender-related crimes is explained in detail, and some data on the perception of safety in the city is discussed. The second part of this chapter introduces the results of interviews conducted with women living in Barcelona. The interviews present insights into the methods women adopt to feel safer and what are the dangers they are scared of. This chapter helps us understand the practical incorporation of theoretical notions.

1.2.1 Barcelona Crime Rates

Barcelona is home to 1.6 million people living on 102 km2 [5], which makes it one of the densest cities in the EU. Most of the year, Barcelona is also flooded by visitors, reaching an average of 12 million people yearly [6] and being Europe's third most visited city [7]. In addition, Barcelona is part of a greater metropolitan region with a population of 5.7 million [8]. This situation has continuously affected the quality of life and the accessibility of public services.

Unfortunately, Barcelona is also infamous for having the highest crime rate in Spain, surpassing Madrid and Valencia by 45% on average [4]. Figure 1 shows that in the first three quarters of 2023, the most frequent crimes were thefts and robberies, representing almost 83K cases in 9 months. The two most common crimes are drug traffic and penetrative sexual assaults, with 1320 and 333 cases, respectively. In addition, according to a study by the city of Barcelona [9], only around 20% of crimes have been reported yearly since 2018.

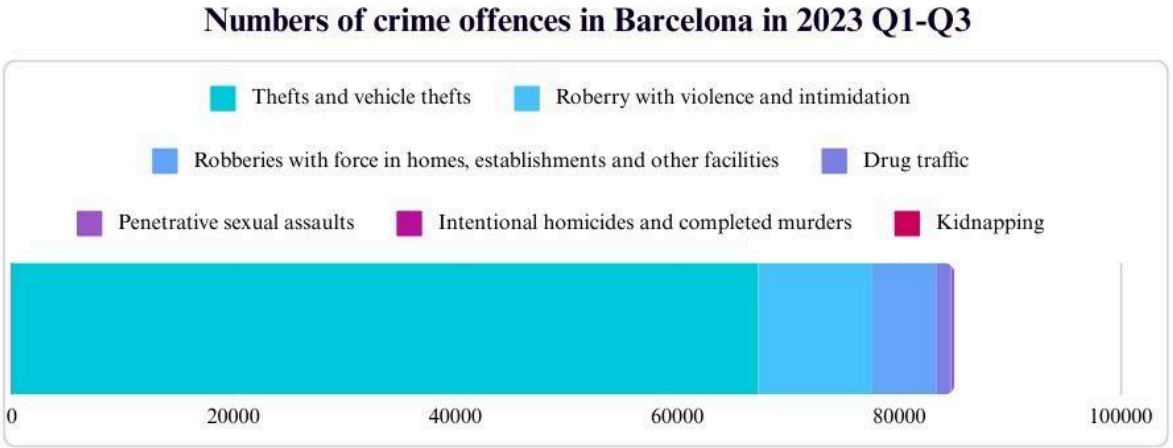

Figure 1: Criminal offenses in Barcelona in the first three quarters of 2023. Source: Created by the author based on [4] data.

Looking at a longer time frame, from 2013, the number of crimes reported in Barcelona oscillated between 120K and 150K per first three quarters until 2020, when most numbers dropped drastically. According to a study by the Barcelona City Council in 2018 [9], 74 % of crimes happen in open public spaces and on public transport. It is believed that the steep decrease in numbers was due to the COVID-19 pandemic, as access to public spaces was limited.

However, in 2021, the numbers slowly climbed, reaching 124K cases. Some of the crime categories, such as drug abuse and sexual aggression, did not even drop significantly in 2020 or 2021, as most of the offenses did due to the pandemic, but rather have had a steady increase ever since 2016, as seen in Figure 2 below.

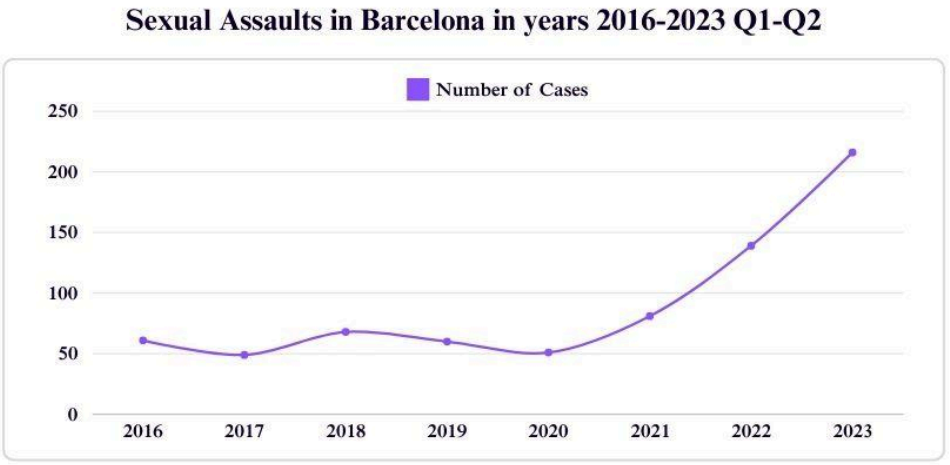

Figure 2: Sexual Assaults in Barcelona in 2016-2023 in the first two quarters. Source: Created by the author based on [4] data.

There is a particular hospital in Barcelona, Hospital Clinic, dedicated to taking care of sexual violence cases for people over 16 years old and reporting to the city. According to their annual reports [10], in the first three quarters of 2022 and 2023, the hospital reported 556 and 587 cases of sexual assaults, respectively. In 2023, 89% of the victims were women, and in 99% of cases, the aggressor was a man.

The crimes committed against women in 2023 have been performed with greater physical violence, causing bodily injuries, surpassing 2022 by 17%. Another alarming aspect, apart from increasing aggression, is substance abuse. It is assumed that in 2023, at least 1 in 5 attacks were performed after deliberate drug intoxication of the victim. According to the report, in 67% of cases of rape, women knew the aggressor, and almost half of the attacks took place at home (victim's home, aggressor's home, or third party). The public and nightlife spaces account for only 16% and 10% of attacks, respectively. The Clinic's Commission stated that in 60% of the sexual assault cases, the victim suffered penetration.

The reporting rate adds additional complexity to the sexual violence in Barcelona. Among the women who received treatment, 45% expressed their intention to report the incident (with 5% having already done so before seeking medical assistance). In comparison, 19.3% stated they do not wish to report, and 31% indicated they cannot decide. Conversely, among men, 42% expressed a desire to report, with none having reported before seeking medical assistance. Additionally, 30% of men stated they do not wish to report, and 27% said they cannot decide. This year, the Clinic's Commission's central postulate is for medical examinations to be evidence of sexual violence. This way of collecting evidence could speed up the process for those victims who do not want to report a crime or cannot decide.

1.2.2 Perception of Security

As the City of Barcelona reports, the Victimization Survey of Barcelona has been conducted annually since 1984. The survey includes 4000 citizens, representing each district according to the population. The surveys aim to inspect the victims' experience and sociodemographic characteristics, location of crimes, perception of security, and perception of civility in the city and the immediate environment. Figure 3, derived from the survey conducted in 2023 [11], reveals that most citizens rate safety in the city between 5-6 out of 10 in recent years.

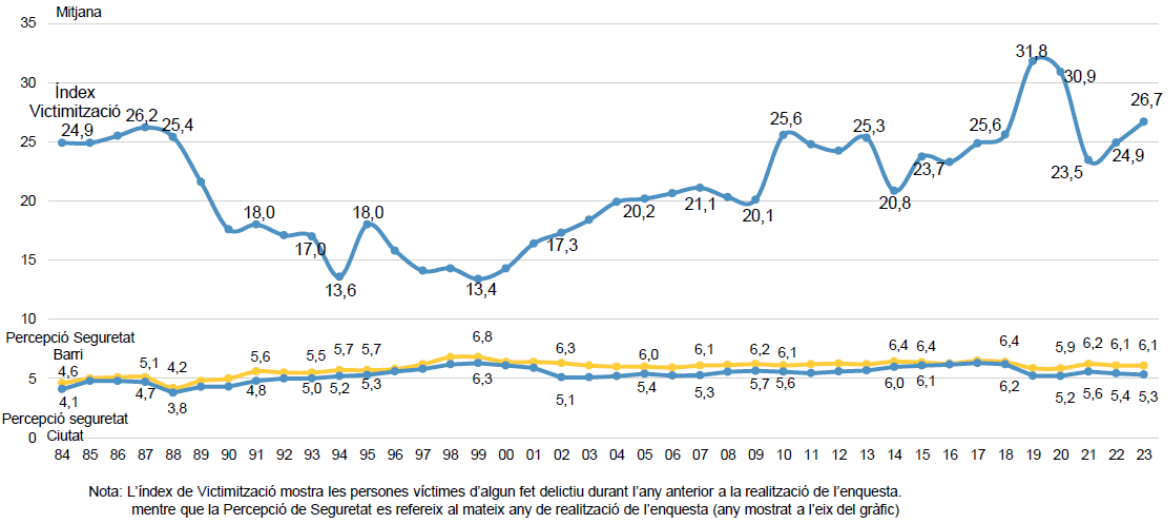

Figure 3: Index of Victimization and Perception of Safety in years 1984 - 2023 in Barcelona. Source: [11].

It can be seen that the level of safety perception in the neighborhood (yellow line) was slightly higher across all years than in the city in general (blue line).

This Figure also shows that the perception of safety has not fluctuated much, even though the number of victims (Index of Victimització) has changed significantly over the years. This intriguing observation could lead to a hypothesis that the correlation between the number of crimes and the feeling of safety is relatively low. This theory can be somewhat confirmed in the following subchapter, where the findings from interviews with female residents of Barcelona are described.

What is interesting is that the perception of safety is similar across genders. Regarding district safety, the average difference between 2018 and 2022 was 0,06 compared to 0,2 in the city's general safety. The difference, however, is too insignificant to draw an unequivocal conclusion. Regarding the overall assessment of Barcelona's safety, 80% of interviewees consistently report that the city's security has worsened or stayed the same over recent years.

In Barcelona, the district affected the most by high crime rates is Ciutat Vella, with 143 crimes per 100 inhabitants in 2022, as shown in Figure 4. The severe criminal record in that district has consistently grown since 2013, with a significant pick in 2018 with a rate of 192. The residency density in Ciutat Vella is 85,700 people per square kilometer, compared to

60,600 in Barcelona. Considering the significant number of visitors to the old town, the density might be an essential factor behind high crime rates.

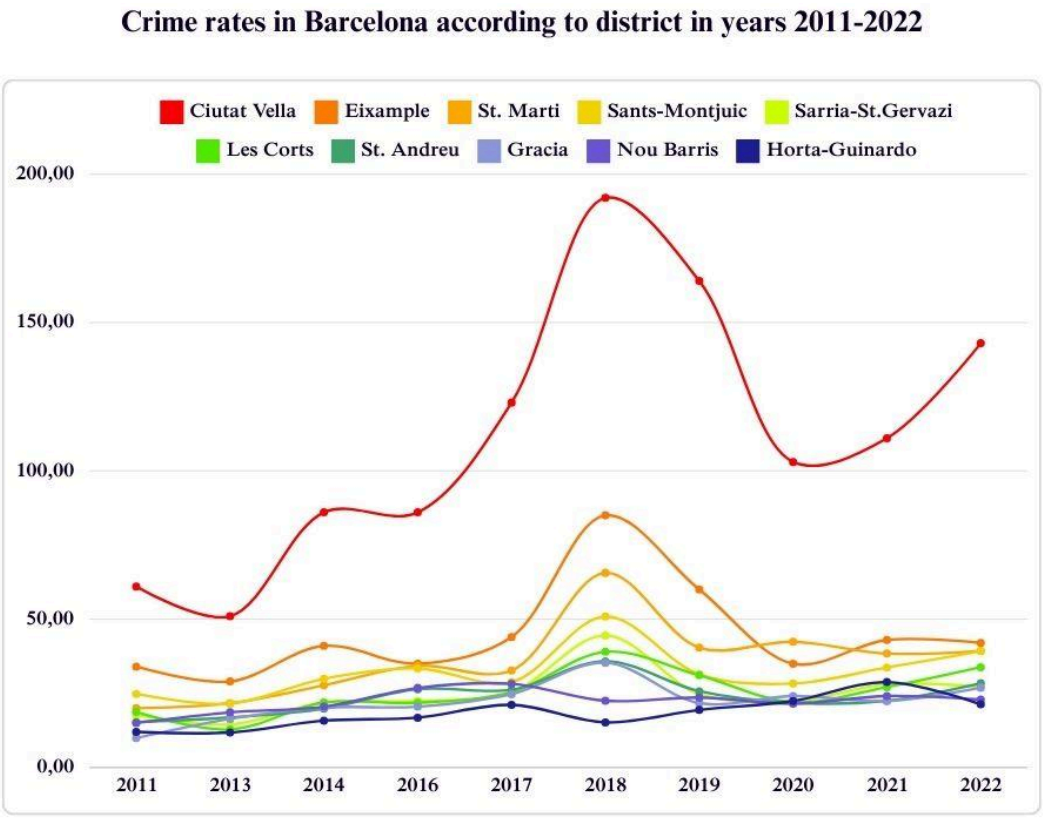

Figure 4: Crime cases per 100 inhabitants according to Barcelona districts in 2011-2022. Source: Created by the author based on [12] data.

It can be noted that Eixample consistently occupies the second-highest position in criminal incidence across the passing years. However, crime rates in Eixample are relatively close to the satellite districts such as St. Marti, St. Andreu, or Sarria-St. Gervazi. Figure 5 depicts Gracia as the safest district close to the city center. Notably, Nou Barris and Horta-Guinardo exhibit the lowest crime rates among all districts.

There was a significant peak in 2018 in most districts, corresponding to more reported crime offenses or higher police and city guard effectiveness. Nevertheless, the second half of 2017 and 2018 were marked by a deep-seated political divide between Catalan separatists seeking independence and the Spanish central government advocating for national unity and preserving the constitutional order. No explicit confirmation was found on how the events correlated with the crime rates in 2018.

1.3 Contribution and Limitations

In this study, a workflow was created to address the issue of unsafe perception and data scarcity. This study was conducted in partnership with a business partner. Thus, the users played an essential part in creating the solution. The process is shown in Figure 5. In the first step, users' needs were taken under inspection. The 24 interviews were conducted in which

people explained their perception of safety and their shortcomings in Barcelona. A crowdsourcing platform for data submission was created based on the defined needs. The platform's first version was tested with ten users who interacted with the service and gave feedback. The improvements were made, and the platform was ready to launch.

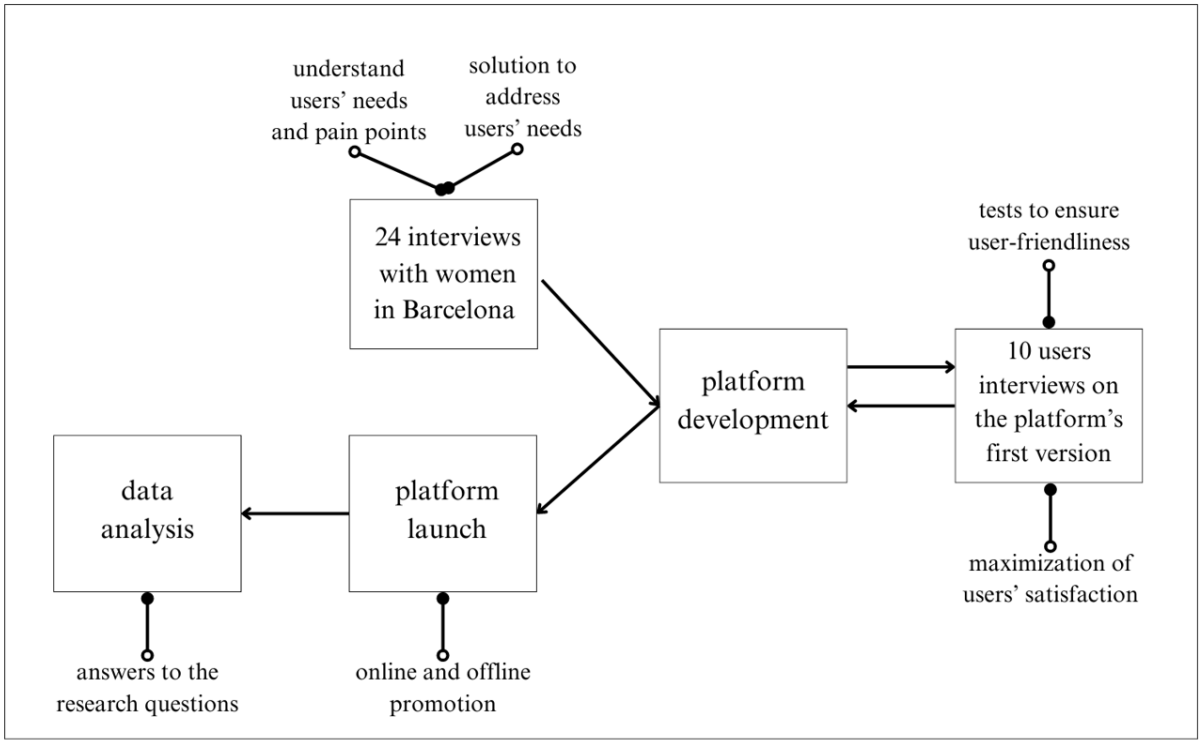

Figure 5: Author's contribution to the thesis. Source: Created by the author.

The promotion took approximately three weeks and included online and offline marketing using the company's resources. The online promotion included Instagram, Facebook, and Reddit content, such as posts and stories. The offline promotion included presentations at different events and posters in public spaces. After the promotion was done, the workflow for data analysis was defined. The main research questions in this thesis are:

1. Are people willing to share sensitive data about the perception of safety?
2. Can the platform make people feel safer?
3. How does infrastructure influence the feeling of safety?
4. How is the perception of safety different depending on gender?

The data analysis process aimed to answer the questions mentioned above. However, the main limitation of this study was that the analysis depended on the quantity of data point submissions. The more data, the more robust the findings and recommendations for the city. It was found that promotion is the essential step that guarantees the success of the established workflow. In the future, more resources must be allocated to obtain comprehensive results.

1.4 Roadmap

This study's objective is to deliver a solution that, on the one hand, will take into account data scarcity on safety perception and, on the other hand, will give citizens the tool to express their pain points anonymously. This thesis defines a data collection and analysis workflow by

considering user-centric design. The platform has great potential to communicate the city’s dedication to safety improvements and inform people about current developments. The safety perception can be improved by taking an active approach to overcoming the problem. The remainder of this paper is organized as follows. Chapter 2 provides information about related work and theoretical background. Chapter 3 presents the adopted approach for the development, and Chapter 4 discusses the study's outcomes. Chapter 5 summarizes the work and gives recommendations for future developments.

2 Literature Review

In this chapter, the main concepts of safety in transportation are introduced. The main emphasis is on the gender perspective on mobility and travel behavior. This is followed by a summary of studies on women's safety in urban mobility, including an in-depth look into the fear of sexual harassment and factors related to urban spaces that cause it. Then, the design principles of inclusive transport systems are analyzed, highlighting several case studies from public transport in cities worldwide and initiatives from private companies. Finally, crowdsourcing approaches and examples are analyzed to collect safety-related data on urban mobility.

2.1 Gender-Based Travel Behaviour

2.1.1 Women's Mobility Characteristics

Women in many countries are still the primary caregivers and perform more household-sustaining activities. This is reflected in their transportation patterns. The trip chaining, for example, is increased by a five-year-old child by 54% for working women and 19% for working men [13]. This indicates that women are more economically sensitive to the cost of transport. While women usually make more trips per day than men, the percentage of women making no trips per day is much higher than that of men [14]. Another characteristic of women's mobility is the working location. The household situation and split responsibilities significantly affect the type of work and the location of it [13].

2.1.2 Factors For Women-Specific Travel Behavior

The factors affecting travel behavior based on gender should be further elaborated. According to a study conducted in 2021 [15], there are several categories where significant differences occur: trip purpose, time of travel, number of trips and chaining, distance, and mode of transport. While women travel more often, they travel smaller distances and are more prone to chaining. The purpose of travel is more likely to be running errands and household-related. Women are also more likely to travel as a passenger or by public transport. The findings from this study are summarized in Table 1.

Table 1: Socio-economic factors affecting women's and men's travel behaviors. Source: [15].

		Travel behavior indicating gender differences				
		Trip purpose	Hours of travelling	Number of trips/travel chain	Distance travelled	Car usage/transport mode choice
	Significant difference	women travel more often for shopping, as companions of other people, and to handle household-related matters	women travel more often outside rush hours	women make more trips per day and within complex travel chains	lower for women and growing together with higher involvement in jobs	women more often travel as a passenger in a private car, use public transport, and walk
Socio-economic factors affecting women's travel behavior	Family roles (e.g. care responsibilities, other unpaid housework)	yes	yes	yes	yes	
	Structure of employment (part-time)	yes	yes	yes	yes	
	Life stage (age, starting work, having children, retiring)	yes		yes		yes
	Pay gap (low wages)					yes

The findings are confirmed by numerous studies [16], [17]. Conditions for the modal choice significantly affect trip planning and differ across genders. Among them are safety issues and time restrictions dictated by work, access to private vehicles, and financial resources allocated for traveling [17]. Importantly, cars are often seen as masculine attributes [18], which also affects women's choice of mode of transport.

2.2 Women's Safety in Urban Mobility

2.2.1 Risks Related to Urban Mobility

According to the definition by Wasselman and Kelly, 2010 [19], "stranger harassment is defined as experiencing unwanted sexual attention from strangers in public contexts." It is believed that the common reason for harassment is the social norms dictated by gender roles and sexual affiliations [19]. While these actions are often misperceived as "human nature" and "unharming" [20], they do cause severe social inequality. Women's fear of harassment limits their freedom to access the city [21], reducing their social and career opportunities.

Once a victim encounters unwanted physical contact, they are hypervigilant and anxious [22]. It also reduces self-worth and leads to mental health problems like post-traumatic syndrome [23].

2.2.2 Protection Strategies

To protect themselves, women have developed tactics to avoid or minimize the risk of harassment. They often use clothes to disguise themselves as men or allow them to run in case of unwanted incidents [24]. They also maintain high vigilance and awareness of their surroundings, followed by avoiding contact [21]. One of the most widely known strategies is in advance route planning and organizing a schedule to travel with a company [24]. In "Understanding How Women Travel," performed by Los Angeles Metro in 2019 [14], we can read that women would wear comfortable shoes like sneakers if they were chased and needed to escape a dangerous situation. Out of the fear of harassment, they would also not wear skirts.

The feeling of safety dictates women's mobility and, consequently, affects city-scale transportation. The fear of crime may affect the increase in car use over public transport [25]. While for many women, mobility issues revolve around safety, the general public does not seem to notice much of the aggression happening in real life, overlooking low-level harassment [26]. To combat harassment, the following measures were suggested:

1. Guidelines for allocating responsibilities;
2. Preventive measures, including awareness campaigns;
3. Coordination and information sharing within all entities;
4. Standardize services for transport providers;
5. Transport department supervision;
6. Pop-up guardianship;
7. Victimization surveys and a victim-friendly environment to report.

More sexual violence proves to be happening in emerging economies that may be related to social norms and women's roles [27].

2.2.3 Low-Income Groups / Excluded Societies

Exclusion and accessibility issues are even more pressing in small cities and the countryside. Externalities produced by transport, like casualties and emissions, adversely affect excluded societies regardless of their limited access to transportation [28]. On the other hand, transport is the enabler of access to education, healthcare, and the job market; thus, connectivity impacts regions positively. That is why the impact of transportation on health is complex. While it does contribute to injuries, potential inactivity, and air pollution, it also promotes active travel and social interactions [29]. In this regard, it is essential to remember that poor women are the social group that walks the most [30], which increases their exposure to these negative and positive factors related to active mobility.

2.2.4 Factors For Safety Perception

Understanding how women perceive safety and dangers in the urban environment is essential. Among empirical studies, the Prospect Refuge theory, Broken Windows theory, CPTED theory, and EoS theory have been widely used to explain fearful emotions in the environment [31]. Prospect Refuge theory assumes that the sense of safety is influenced by visibility-providing elements (mostly lighting), while shading elements (such as greening) provide opportunities for potential offenders to hide, creating the perception of fear. Furthermore, according to this theory, pedestrians feel more secure when they see the possibility of fleeing from potential offenders. This is why the openness of city streets is desired instead of overly closed streets, which can prevent pedestrians from escaping when they are victimized. According to the Broken Window theory, the sense of fear can be caused by perceived disorder, generally reflected through visual symbols in the environment, such as graffiti, litter, poorly maintained landscapes, and buildings. Another factor influencing the perception of security is the existence of natural and artificial surveillance, as explained by the Eyes on the Street theory. Natural surveillance is developed by people or motor vehicles moving around the streets, while artificial surveillance is created using closed-circuit television cameras (CCTV).

Crowdsource-based studies on the perception of safety in urban spaces confirm the factors mentioned above. In the research conducted by the XYX Lab and CrowdSpot in the state of Victoria [32], women and gender-diverse people marked spots in the city where they felt safe or unsafe, providing the main reason for this perception (Table 2). Well-maintained, open, and easy-to-navigate spaces contributed most to the feeling of safety. At the same time, poor lighting, behavior from others, and low natural surveillance were the leading causes of people feeling unsafe.

Table 2: Key factors influencing the perception of the safety of women and gender-diverse people after dark in Victoria, Australia; n = 5,533 submissions [32].

Reasons for a place feeling safe		Reasons for a place feeling unsafe	
Well-maintained	70%	Poor lighting	58%
Can see ahead	69%	The behavior of others makes me feel uncomfortable	46%
Pathway is safe	68%	No people around	36%
Easy to navigate	52%	Hard to see what and who is ahead	36%
Clear exits	48%	It feels uncared for	26%
Lighting is good	47%	Concerning behaviors	22%
Buzzing / Good vibes	43%	Isolated / Unsurveilled	21%
Not too crowded	41%	I feel trapped here	20%

2.3 Designing Inclusive Transport Systems

2.3.1 Public Transport - Challenges and Solutions

In 2019, the UN published a compendium of international practices for safe cities and public spaces for women and girls [33]. Three use cases in the compendium focus on safety in public transportation. In Port Moresby, Papua New Guinea, according to the scoping study performed by UN Women [34], 90% of women and girls experienced some form of violence when accessing public transport, including on buses, waiting at bus stops, walking to and from bus stops, or in taxis [34]. As a special temporary measure to improve the situation, in 2017, the city launched women-only buses called Meri Seif Buses (MSB), giving access to safe public transportation to over 80,000 women and girls annually. As a more sustainable measure, comprehensive training was conducted for both male and female bus drivers, improving their awareness of gender equality, human rights, and different forms of Violence Against Women (VAW), as well as increasing the number of female drivers, which has a positive impact on the perception of safety.

In Quito, Ecuador, protocols for easy reporting of sexual harassment (SH) were created, leading to an increased number of reported and prosecuted cases on SH against women and girls in public transportation. In Cairo, Egypt, a comprehensive study of gender-specific travel patterns was conducted, identifying the biggest safety issues of women in public transport, such as frequent experiences of SH, poor quality of footpaths and bus stops, and lack of priority seating. The study led to a more inclusive and safer plan for implementing the new Bus Rapid Transit (BRT) in Cairo by mid-2024.

Another good example of designing gender-sensitive transport is Canada, where transport-related policies and programs must undergo a Gender-Based Analysis. This analysis helps decision-makers assess the impact on men, women, and gender minorities separately [35]. The institutional support of GBA includes but is not limited to, employee training and material guidance on gender bias, high integration of GBA into transportation services worldwide, and assessment of data insufficiency [36].

2.3.2 Safety-oriented Commercial Transport Services

It is more than just the public sector identifying the safety risks for women in transportation. Private companies have also been active in this area, introducing services and features to address this topic. For example, the sexual harassment risks in taxis have been acknowledged by several ridesharing companies such as Lyft and Uber, who introduced 2023 a new feature to match/request women and nonbinary rides, improving the perception of safety for drivers and riders [37]. In the e-scooter area, a striking gender gap was identified by Voi in 2022: over three-quarters of women (79%) reported not feeling safe using e-scooters [38]. 83% of respondents said that docking locations can be an obstacle to riding if they are not in safe and useful areas. To address this issue, Voi launched a Gender Safe Parking Standard, which

involves the technical assessment of parking locations based on several indicators directly related to women's safety.

2.4 Crowdsourcing Platforms

Designing inclusive transport systems requires public participation to achieve greater legitimization and acceptance of public decisions and citizens' satisfaction [39]. There are various forms of public participation, such as surveys, public hearings, workshops, and focus groups. With the development of digital media, there are also new approaches to public participation that do not require the physical presence of citizens. One is crowdsourcing, a method of collecting input from a large group of people, e.g., to solve a specific problem that affects them [40]. It usually uses open-source online platforms that allow data incorporation, modification, and synthesis. Some popular types of platforms include wiki systems and geocrowd mapping.

Crowdsourcing has been successfully used in various cities worldwide to create safe public spaces. A lighthouse example can be the above-mentioned study on the perception of safety in the state of Victoria, Australia [32]. In collaboration with 25 local and state government partners, Monash University XYX Lab and CrowdSpot they used a digital mapping platform to crowdsource nearly 6,000 submissions in the form of pins, comments about those pins, and clicking of the support button on a pin over thirteen weeks from April to July 2021. The data was used to fill out the data gap of the local authorities and help improve perceptions of safety in the state's public spaces. Another study as part of the YourGround project was commissioned in the state of New South Wales in 2023 and is presented in Figure 6.

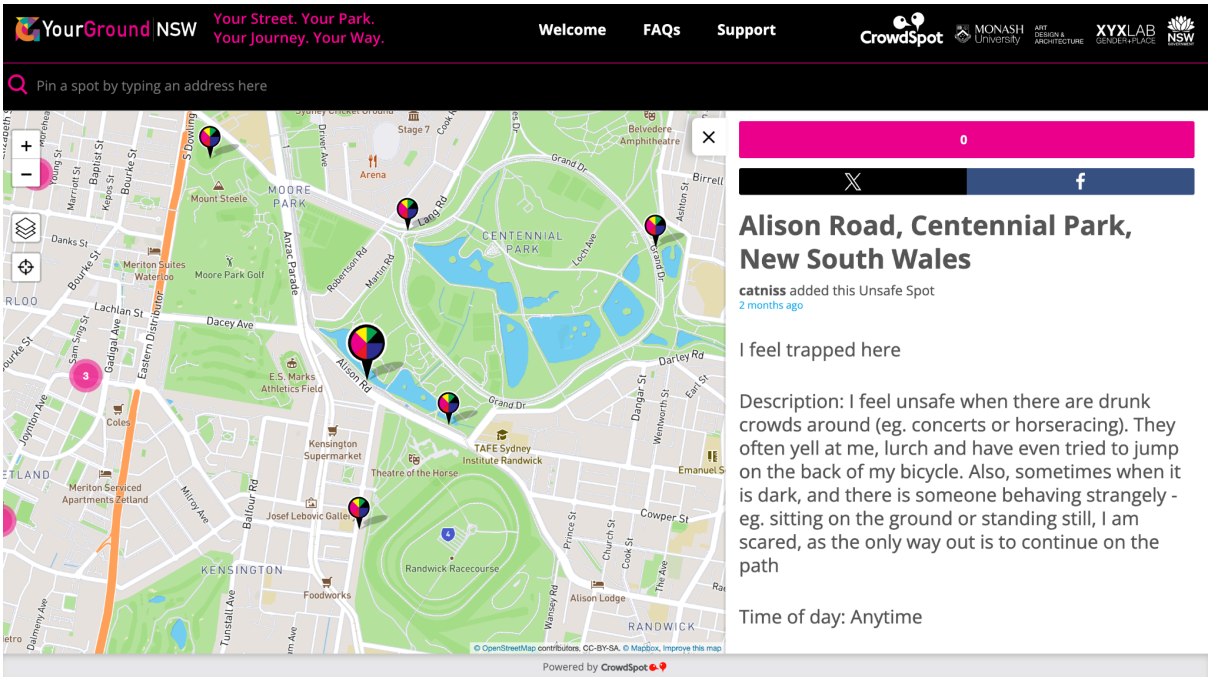

Figure 6: Crowdsourcing map used to collect data on safe and unsafe experiences of women and gender-diverse people in cities and towns in New South Wales, Australia [41].

Another, more ‘bottom-up’ example of an effective crowdsourcing platform is the HoodMaps (https://hoodmaps.com), a web app created by a self-taught software developer, Pieter Levels, in 2017, written in plain HTML, CSS, and JavaScript code. The app allows citizens and visitors to mark areas associated with six stereotypical groups of people (Offices, Rich, Hip, Tourists, Uni, and Normies). It aims to give a ‘quick overview of what a city is about’ [42]. Users can also leave tags with comments on specific spots. These comments become visible publicly after receiving a sufficient approval score from the community (every visitor can add or remove a point by ‘thumbs up’ and ‘thumbs down’). As an unsupervised project, HoodMaps became a primarily satirical tool to reflect the city stereotypes; thus, the research value of collected data is arguable. However, the platform became the most popular urban crowdsourcing map globally, with more than 500k monthly visitors (as of March 2024). This is why several aspects of HoodMaps are relevant for this thesis: user-friendliness, no barriers of entry (no login or personal data required), attractive data visualization (color coding), scoring system, and descriptive feedback. The last aspect is especially interesting from the perspective of the perception of safety. In Barcelona (Figure 7), many comments with high approval scores relate to the dangers reported by citizens/tourists, e.g., ‘Airbnb burglaries and scammers,’ ‘Drug dealer street,’ ‘Avoid this area,’ ‘Pickpockets everywhere.’

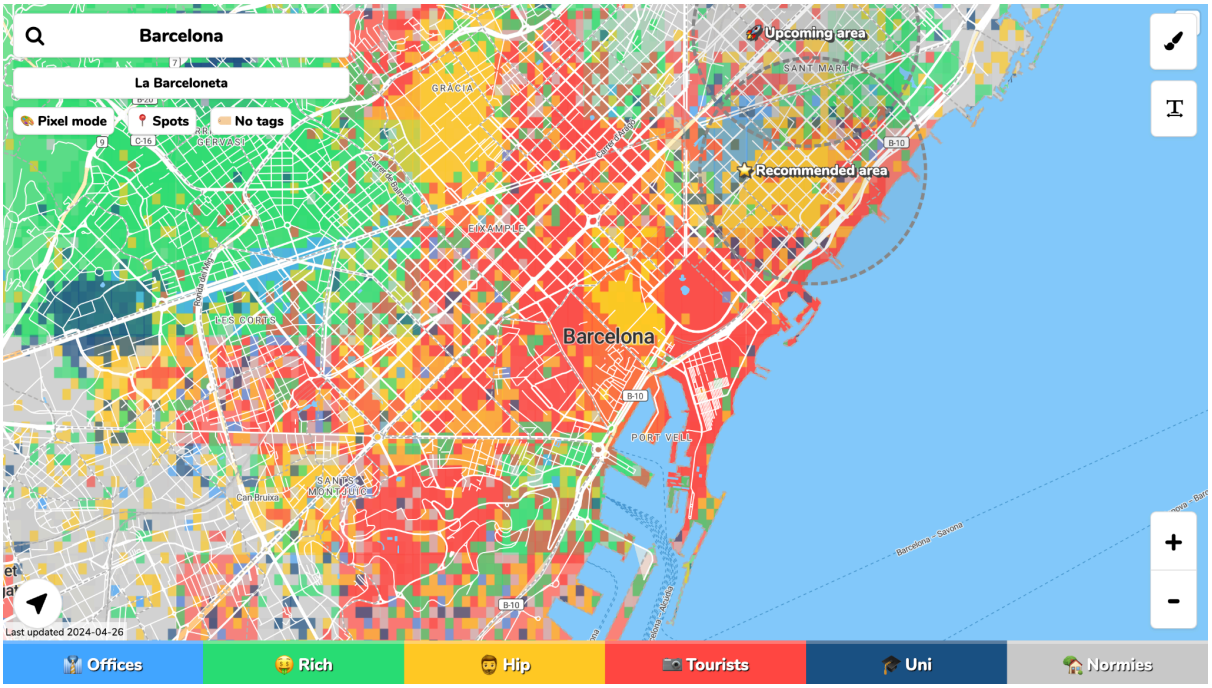

Figure 7: Crowdsourcing map used to collect data on urban areas in Barcelona [43].

Based on the examples mentioned above, several challenges and limitations related to using crowdsourcing can be identified as being related to providing reliable input for decision-making. First of them is the digital divide and representation bias - only some have equal access to digital tools and skills, leading to the overrepresentation of tech-savvy individuals and skewed representation of community preferences and needs. Another problem is the quality of input, which is more difficult to control in an anonymous environment with no supervision of the data collector. The sense of anonymity can also lead to malicious behaviors of the crowd, such as misinformation and manipulation of input data, which is

especially dangerous if the data collection and its visualization are not moderated. Crowdsourcing also often leads to privacy concerns, with participants needing help to provide personal data due to the fear of misuse. On top of this, similarly to other participatory methods, citizens involved in crowdsourcing may become disengaged if the activity is not directly linked with tangible outcomes. Finally, publicly available crowdsourced data may stigmatize urban areas struggling with inclusion.

3 Methodology

According to the findings from the literature review, the perception of safety differs across genders. In the methodology, a deeper understanding of safety perception was founded, which included interviews with citizens and the communication platform. The main research topics in this thesis are:

1. Are people willing to share sensitive data about the perception of safety?
2. Can the platform make people feel safer?
3. How does infrastructure influence the feeling of safety?
4. How is the perception of safety different depending on gender?

To address the topics, a data collection tool was needed where people could report their perception of safety and the main factors that influence it. An online crowdsource service was created and designed both for mobile devices and computers. The tool's methodology involves feasibility analysis, data collection, analysis, and service promotion.

This thesis used Grammarly to provide stylistic and spelling correction support.

3.1 Feasibility Study Based On Interviews

Interviews were conducted to deepen the understanding of the safety perception of women and queer people in Barcelona. The main objectives of the interviews were to assess the techniques that help people feel safe and to understand what makes people feel unsafe in general. This part validated the first research question regarding willingness to share feelings on safety.

3.1.1 Interviews Description

The interviewed participants were women and queer women aged between 25 to 45 years old who currently reside, used to reside, or visited Barcelona. The ethnicities within the group were diverse and are listed in Table 3 below:

Table 3: Number of participants according to nationalities.

Nationality	Number of participants
Chinese	10
Indian	2
Spanish, Catalan	2
Pakistani	1
Indian	1

Kazakhstan	1
Greek	1
Polish	1
German	1
French	1
Italian	1
British	1
Venezuelan	1
TOTAL	24

The topic of safety and its lack was considered potentially sensitive. The participants shared their stories of where they felt vulnerable or when they were victims of harassment or abuse. The form of a 30 to 60-minute interview was chosen to ensure a friendly and safe environment for the participants. Due to the time intensity of the interviews, 24 were conducted from Nov 20th to Dec 20th, 2024. The scope of the interview, together with the questions, is listed in Appendix 2. During the interviews, the participants were asked questions corresponding to the following categories:

1. General questions: name, age, and profession.
2. Everyday mobility: transportation modes choice during the day and night, common destinations, and trip duration.
3. Safety: most frequent fears and coping mechanisms.

3.1.2 Conclusions

The interviews allowed us to draw general conclusions about how safety is perceived and ensured among the participants. It also provided some general understanding of which parts of the city could be more problematic.

1. El Raval and El Born neighborhoods are considered the least safe in Barcelona; women enter them only under conditions like company or daylight.
2. Meticulous trip planning and calling a friend or partner are the most popular tactics for ensuring safety.
3. The most common external factor providing safety in public spaces is seeing people around. However, this applies only if the people's appearance is assessed as pleasant and ‘uninterested.’ Women usually fear drunk-looking and acting weird, visibly foreign ethnicity big groups of males.

4. Deserted spaces and narrow streets were often considered dangerous.
5. Participants actively search for solutions that can help them feel safer.

The interviews proved that safety perception is subjective and based on individual experiences and trip circumstances. It was noted that the level of safety in the country/region where participants were brought up plays a massive role in the perception of safety in Barcelona. Another common characteristic was familiarity with places and the Spanish language, which elevates the sense of safety. There is a big difference in perception of safety when traveling alone and with a company. Women who travel with kids are much more vigilant and self-aware of their surroundings. On the other hand, traveling with a company like a friend or a partner provides a sense of safety.

The complexity of the safety perception was also shown in situations where participants felt in danger without being able to identify it. On the other hand, some indicated a “good vibe” as the leading factor for safety. Therefore, no clear conclusions can be drawn about what women are mostly scared of when it comes to night commutes.

While safety actions differ across ages, ethnicities, and neighborhoods, most interviewees consider safety factors while commuting. Participants were willing to prioritize safety over price, convenience, and trip duration (taking a taxi or a detour). Some create communities where they look for company while traveling at night and share incidents or places to avoid while moving around alone. Most of them actively look for technological solutions to make themselves feel safer.

On the surface level, most interviewees reported feeling safe in Barcelona. However, they have adopted multiple mechanisms that reinforce safety. A certain level of shame and guilt is also attached to the feelings, which may indicate how deeply the problem is rooted. The participants shared their stories willingly, even if their experiences in night commutes were difficult or traumatic. They also indicated that they were happy this matter got broader attention and was finally addressed. This is a positive answer to the research question regarding the willingness to share feelings on safety.

Comparing the observations from the Victimization Survey from 2023 and the interviews, familiarity with the surroundings plays an essential role in the perception of safety. In the Survey, the feeling of safety in the neighborhood was consistently scored higher than in the city. This is also true for the neighborhoods with the highest crime rates. The other conclusion might be that the perception of safety often does not only correlate with the number of crimes. There is a high probability of perceiving the neighborhood as generally safe if other criteria are met (the neighborhood has a good reputation or is very familiar).

3.2 Data Collection

In the data collection part, four main stages are presented. The first stage is the development of two applications; the second stage is interviewing users and incorporating their feedback; the third stage is preparing the application for broader public use; and the fourth stage is

promoting the application. At the end of the subchapter, the architecture of the final application is described.

3.2.1 Applications Development

The most significant inspiration for this thesis was a collaborative project, YourGround [32]. It is comprehensive research based on survey data from women and gender-diverse individuals on places' safety according to the time of the day, type of environment, purpose of the trip, means of transport, and activity. The information gathered is later transformed into a report showcasing the findings.

A simplified version of a crowdsourced platform was developed under this study due to time and resource constraints. The next motivation for choosing a more straightforward version was to make the user journey fast and straightforward. This is why the main inspiration for the layout was a crowdsourced map developed in GitHub [44]. The map has only one sidebar with a fixed positioning regardless of the user's input. The way the application was deployed in the GitHub code was, however, outdated, and some other system architecture was chosen. The architecture is described in the subchapter Architecture.

After a thorough understanding of how crowdsourced services work, the development of the service started. Two versions of it were developed in parallel with two different levels of data accuracy. In the next paragraphs, the specifics of each application are described. The final decision on which application should be employed was made after the users' feedback session.

The most important functionality of the first application (further referred to as MVP1) was to drag and drop the pin in the desired spot. A standard Google Maps pin was used, as presented in Figure 8. After dragging the pin, the input was populated with the address. The user could use only one place on the map, describe it as 'safe' or 'unsafe,' and identify suitable quality using drop-down menus. Only one factor was available to choose due to the application's simplicity. After submitting the data, the sidebar closed.

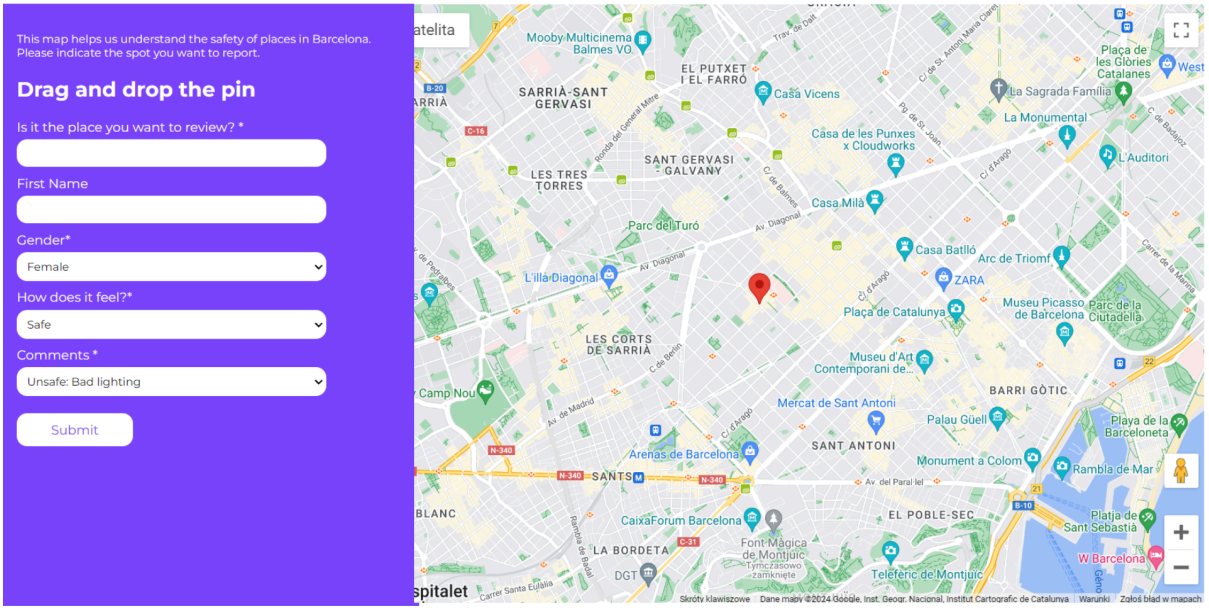

Figure 8: The screenshot of the MVP1 of the application. Source: Created by the author.

The reason for allowing users to mark only a single point was a seamless user journey and the intuitiveness of interacting with the pin. A standard Google Maps pin was used to ensure that.

The second application (further referred to as MVP2), presented in Figure 9, allowed users to report an area. The users could draw as many vertices as they wanted and close the polygons by clicking on the first vertex. The polygon was displayed on the map, and the user could draw only one shape in one submission. To edit the polygon, the user needed to draw the polygon once again. The only difference in the sidebar was that the address was not displayed there.

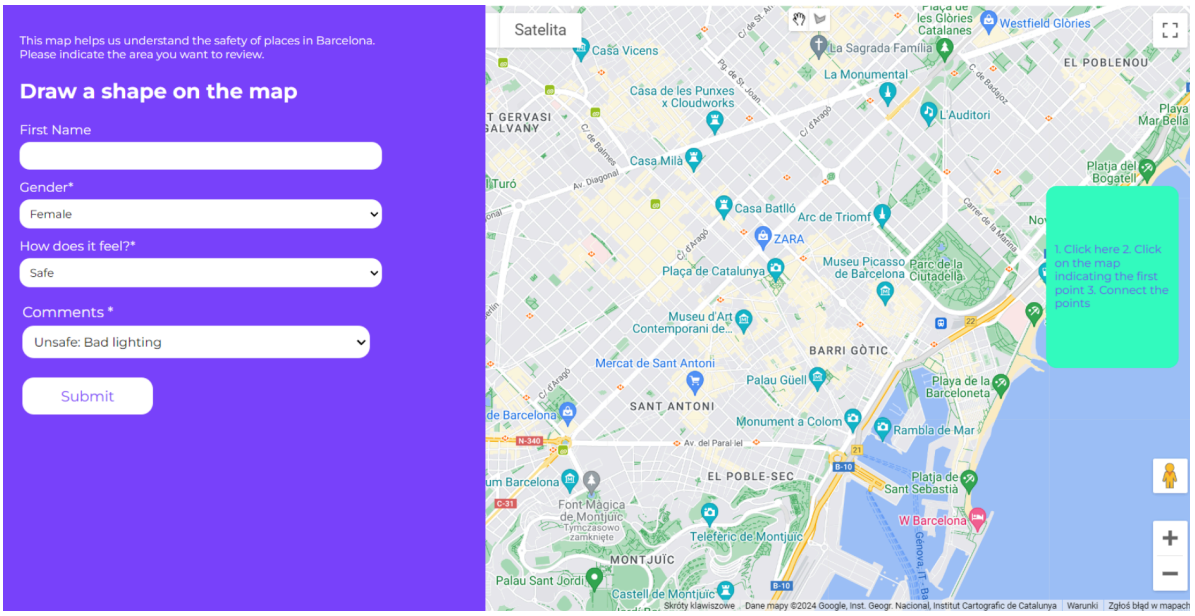

Figure 9: The screenshot of the MVP2 of the application. Source: Created by the author.

The motivation for this type of data input was higher data accuracy and coverage for the data analysis. It also seemed more logical for the potentially dangerous space to be a whole neighborhood rather than a single point.

3.2.2 Users' Feedback

To ensure a user-friendly interface, interviews with potential users were performed. The users were chosen from friends and supporters of the Your Way Home initiative. Twelve users were interviewed in online (2) and offline meetings (4) and through Google Forms (6). The interviews were conducted on computers, as mobile-friendly functionalities were added afterward. The questions are presented in Appendix 3.

The users were divided into three groups: the first one testing MVP1 (six people), the second one testing MVP2 (four people), and the third one testing both (two people). The main objective of the interviews was to assess the user-friendliness of pinning a spot against drawing a shape. It was assessed by open questions and observations of users' interaction with the application as they shared the screens. The second objective was to assess the intuitiveness of the service. The duration of successful submission measured this.

The interviews proved that indicating an area is more interactive, fun, and accurate. However, simultaneously, the interviewees faced technical obstacles, such as needing to learn how to mark the area, and the interface proved to be only PC-friendly. In the end, the submission rate for the MVP2 was much lower, with only 3 out of 6 people completing it successfully. On the other hand, marking one single point on the map was understandable for most interviewees, and the interaction time was shorter. User-friendliness was assessed as a crucial part of crowdsourced services. This is why MVP1 was chosen to continue the development, compromising the accuracy of the submitted input.

Another important part of the service that users gave feedback on was the reasons for feeling unsafe and safe. For MVP1 and MVP2, the most frequently mentioned factors were derived from literature and interviews with women. After the users' interviews, the list was updated. The final version is shown in Table 4.

Table 4: Safe and unsafe feeling drivers derived from literature, user interviews, and interviews on women.

Unsafe	Safe
Bad lighting	Good lighting
Poor infrastructure	Good infrastructure
Narrow street	Wide street
Intimidating people	Easy to navigate
Lots of pickpocketing	Lots of people around

Bad vibes	Good vibes
Bad experience	Seems familiar

Based on the users' feedback, it was decided that the factors should be in the form of checkboxes, and multiple choice should be available. Users also pinpointed that they would appreciate an additional field for text input if none of the factors applied or if they want to share additional details. The last feature users lacked was a screen after hitting submit, confirming the submission. After a thorough consideration, MVP1 was chosen to continue with, and all suggestions were added to the application.

3.2.3 Last Refinements

After incorporating the users' feedback, the application content and display were ready. However, the platform must be prepared for the general public to access. In this stage, there were three priorities: prepare the platform for the local context, ensure data privacy, and ease of accessibility.

The terms of use and the privacy policy were defined and published in the first step. The task required a thorough understanding of the service and its development in the future months. The terms of use described who and under which conditions could access the application, and the limitations on liability and intellectual property were explained. The main inspiration for this document was the Terms and Conditions of a similar service [45]. In the privacy policy, the data collection context was extensively covered. The documents were drafted, and a lawyer from Your Way Home reviewed them and prepared the final version. In the last step, both documents were embedded in the landing page of Your Way Home website. The acceptance checkbox was placed in the application, and the documents were linked. The submission was only possible after agreeing to the Terms of Use and Privacy Policy.

Translating the application into Spanish and Catalan was another important aspect of making the application ready for public use. The application targets residents of Barcelona, and even though the city is very international, it should be accessible in the local languages. Your Way Home website needed the translation, too, as it was part of the user journey. The first draft of the translation was done using ChatGPT [46]. A Spanish and Catalan native speaker reviewed it and gave feedback. After incorporation, the application and the website were translated, and the links for switching the languages were added to both.

It is assumed that most users will access the application on their mobile phones. The service will most frequently be used when people are out at night or during the day, and some event triggers them to submit a place. As mobile-friendliness ranked high on the agenda, some basic adjustments were made. The service proved mobile-friendly, and users could understand how it works and interact with it. It is understood that technological issues will deter some people from using this service. Adjustments could be made in the future to close the gap.

The next important aspect was the accessibility to the application. The link to the application generated from the Google Apps script looked like this:

‘https://script.google.com/macros/s/AKfycbwxUjmgO8sjj-Pmg2INnPWXkeda0hB8PlVDdq3TrlGUtxlJU-MTSaqQNgsQ90w-jXVp/exec’.

It was very long, and users needed help to remember it. This would decrease the chances of propagating the service through word of mouth. For that reason, a redirection link from yourwayhome.eu domain was needed to navigate to the map service. The final link was barcelonasafetymap.yourwayhome.eu. In this way, two possibilities for accessing the application were created. The first is to navigate to the link directly in the browser: https://barcelonasafetymap.yourwayhome.eu/, and the second is through a button on Your Way Home website: https://yourwayhome.eu/.

Once the main issues with the application were fixed, it was decided that users needed more context on the objective of the application and who Your Way Home is. This is why website design and content changes were needed. The previous narrative revolved around the safety of women and queer people after dark. However, the service has undergone a substantial pivot, and updated communication was needed. The website's main objective, as it is today, is to encourage visitors to enter the Barcelona Safety Map, where the broader context of the project is given.

As this master’s thesis is also a part of an industrial project performed with Your Way Home, the business opportunities needed to be discussed. The application acts as a research tool and is a stand-alone product of Your Way Home. It was essential to understand how the map would position the company in the nighttime safety market and how this project could be used to obtain the first customers. This is why it was decided that an optional input of an email address is needed in the submission form. All the users who fill it out will receive additional information on the project and its results.

After considering users' feedback, business objectives, and technological constraints, the final version of the service was created, as seen in Figure 10.

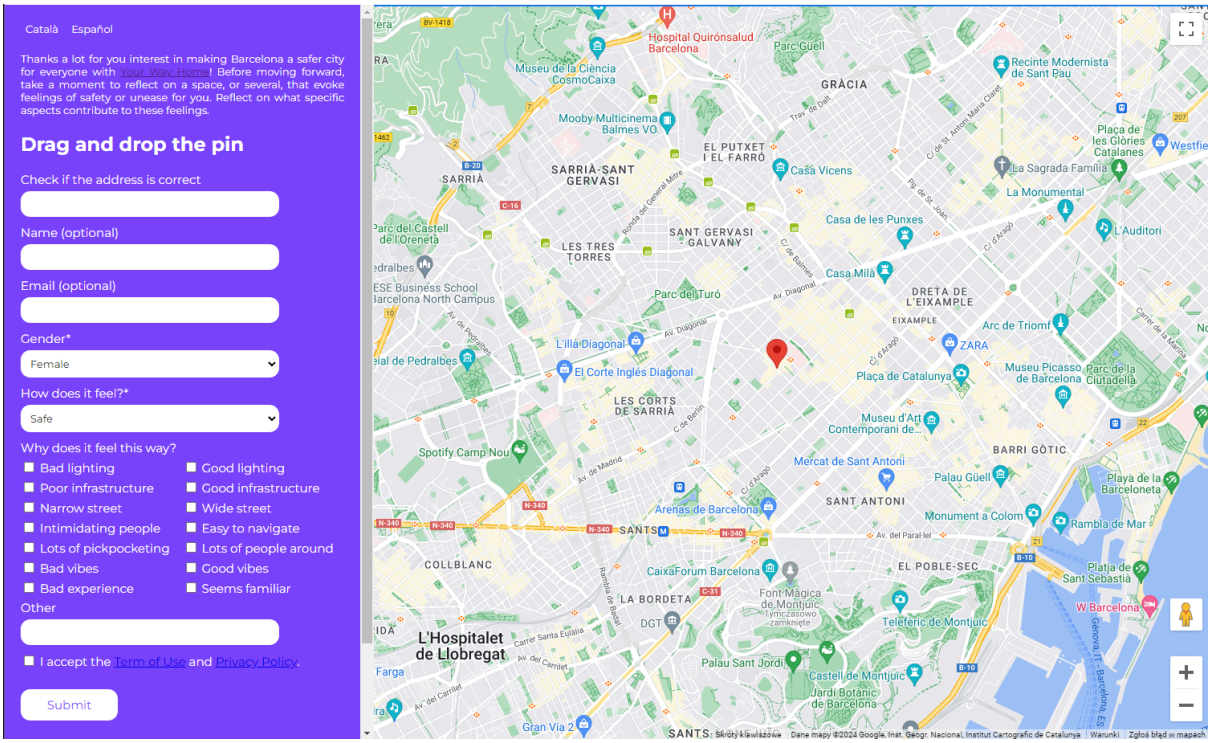

Figure 10: Final version of the application. Source: Created by the author, available at https://barcelonasafetymap.yourwayhome.eu/.

The final version included Catalan and Spanish switch buttons and text explaining the context of the project. The users had four open textual inputs, two drop-down menus, and several checkboxes, one of which was mandatory. At the end of the sidebar, it is explained that this platform is part of a master's thesis, and an email address is given if questions or doubts arise.

3.2.4 Architecture

The application's main objective was to build an easy-to-use, simple tool enabling reliable data collection. This is why basic technology was used without advancements in databases and software. The code's architecture is shown in Figure 11 and combines HTML, CSS, JavaScript, and external services integration like the Google Maps API.

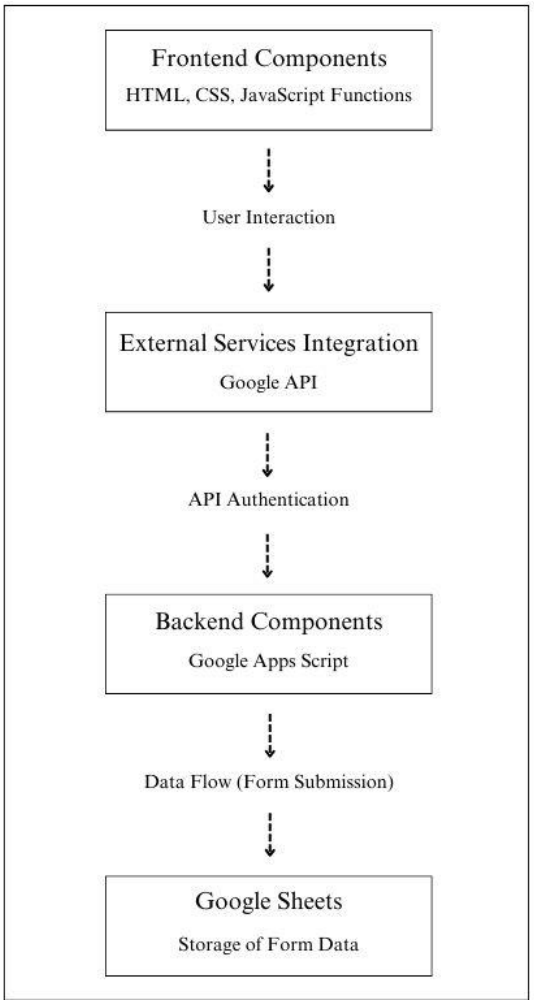

Figure 11: Generic description of the System's Architecture. Source: Created by the author.

The application's layout and content were defined in an HTML file, 'index.html,' including labels, input fields, paragraphs, and buttons. The visual properties of the elements were defined in CSS. To ensure correct user interaction, the code included several JavaScript functions: 'submitForm(),' 'redirectTo(),' 'initMap(),' 'updateLocationInput(),' and 'validateForm(),' responsible for submitting the form, redirection to other services (Spanish and Catalan version), map initialization, location updates, and form validation, respectively. A Google Maps JavaScript API was integrated to display the interactive map. The API Key was provided to authenticate the application's use of Google Maps services. Thanks to the access to Google API, some technical support was used, such as the 'updateLocationInput()' function. One of the most important functionalities of the application was enabled by the 'submitForm' function, which the user called by clicking the submit button. The function validates the form inputs, hides the sidebar, displays a confirmation message, and sends the input data to a server-side script using 'google.script.run.onSubmitForm()'. As the application might be accessed on different devices and screen sizes, some essential design tools for responsiveness were incorporated to ensure proper display. The CSS styles adjusted the layout based on the viewport size.

A simple code in Google Apps Script handled backend functionality, including receiving form submissions and storing them in a Google Sheets spreadsheet. The first Google Apps script-specific function used in the code, the 'doGet()' Function, was responsible for rendering the HTML content of the web application to users. When they access the web application URL, it generates an output originating from the 'index.html' file: 'HtmlService.createHtmlOutputFromFile('index')'. The second function in the code, 'onSubmitForm(formData),' was called when the form on the front end was submitted. The form input submitted by the user is contained in 'formData.' The function accesses the Spread Sheet, defines the last active row, and increments it by 1 to append a new data row. The last step converts the checkbox elements to a comma-separated string using join(", ") and stores the data in the spreadsheet. Each new submission is appended to a new row in the spreadsheet, according to the representing column.

3.2.5 Promotion

One of the success measures of the project in Barcelona is the number of submissions. Much of the work performed in this thesis was devoted to accurate and well-thought communication and marketing. Delivering the platform to the public took much work as limited financial resources were available. The promotion occurred online, offline, and through dedicated events.

The International Women's Day on March 8th, 2024 was chosen for the launch. The graphics for offline and online marketing were designed as seen in Figure 12:

Figure 12: Promotion materials for online marketing on the left and offline in the middle and the right. Source: Created by the author.

The graphics dedicated to online marketing were shared on Your Way Home's Instagram and LinkedIn platforms. They were also posted on Facebook Barcelona's groups for women and Reddit. Some significant traction was observed, and the first submissions were made.

The other graphics were posted in public spaces and bus stops. Offline marketing was more time-consuming but also proved to be more effective. It was believed that users are willing to assess the level of safety when they are out actively experiencing the lack of it.

The other marketing streams were conducted through meetings and presentations of the projects to third parties. This included a presentation for EIT Urban Mobility students at Universitat Politècnica de Catalunya. As an initial validation of the interest in the application and its data was conducted, some meetings with city and university representatives were conducted. The UPC Citizen Science Organization was interested in developing a similar service at UPC's campus, and some work beyond the scope of this thesis was performed in further negotiations.

3.3 Data Analysis

In this part, the methodology of analyzing the collected data is explained. Firstly, the data is preprocessed and prepared for further analysis. After that, spatial distribution, correlations, and patterns are derived to answer the research questions:

1. How does infrastructure influence the feeling of safety?
2. How is the perception of safety different depending on gender?

Additional data from external sources were added to support and better understand the analysis's outcome.

3.3.1 Data Preparation

In the first step, the environment was prepared, and the data from the online resource was downloaded. At this stage, some cleaning was necessary. The rows with missing addresses were deleted as they contained insufficient information, and the format of the rows was adjusted manually. Outliers containing, for example, addresses in the sea or Madrid were deleted. There were also some inconsistent rows where someone pointed out an unsafe space but checked the factors for a safe spot. In such cases, the 'How does it feel?' column was regarded as a mistake and was reassigned to an unsafe value.

After basic cleaning, the data was geocoded using Google API (googlemaps library). A geocoding function was defined that takes the address as an input and applies the function from the googlemaps library gmaps_key.geocode(). The latitude and longitude are the outputs of this function and are assigned to a dedicated column in the data frame. After string manipulation, the data frame is transformed into a geodata frame using columns for Longitude and Latitude, assigning a point's geometry to each observation in EPSG 4326.

As a last step of data preparation, the Reason variable was changed into dummies to enable further data exploration. The variables with the most missing values, such as name and Email, were deleted. Gender and Safety were transformed to bool values (female=1 and unsafe=1).

3.3.2 Gender Perspective

This part aims to understand the influential factors for men and women in their perception of safety. To achieve this outcome, the data frame was grouped by gender and reasons for feeling safe or unsafe. This resulted in a table with the reasons for feeling safe and unsafe and their gender distribution. Another insightful gender-related statistic was the number of submissions from each group and the distribution of safe and unsafe feelings.

3.3.3 Spatial Distribution

This part is dedicated to the spatial distribution of the pins. Such analysis could also contribute to answering the research question regarding the influence of infrastructure on safety. A method for point pattern visualization was needed to understand the spatial distribution of pins, and hex binning was utilized first. Hex Binning overlays a grid of squares of hexagons and counts how many points fall within each. Some specific areas in the city suffered from points cluttering, and the grid was supposed to provide better information on the distribution of the pins. However, this method did not prove to capture the real meaning of the data as the points needed to be distributed more densely. This is why a second method of kernel density function was utilized. This method lays a grid of points over the space of interest where it places kernel functions. In the next step, the functions count points around them with a different weight based on the distance. The results are later aggregated to generate a global surface with probability. This feature of KDE provided better coverage of the map even if the points were scarce and a heatmap could be constructed.

The second part took a closer look at the unsafe pins. A weights matrix was used with five nearest neighbors to understand the underlying pattern of the points. The KNN was chosen because, at this point, no other spatial relation is known other than distance. The dataset that the algorithm is applied to is relatively small. However, it is quite sparse, so five neighbors were chosen. The spatial lag, calculated afterward, presented the behavior of the unsafe pins in their immediate surroundings. A comparison between a map with unsafe pins intensity and a map with spatial lag was produced to present the differences in the interpretation.

3.3.4 Principal Component Analysis

The principal component analysis was conducted to inspect the data closer and reveal some underlying patterns, such as clusters. Data visualization was enabled with dimensionality reduction, simplifying all the dummy variables. Before applying PCA, it was ensured that no missing values or outliers were present and that the dataset contained only numerical variables. Another step in the preparation was scaling the data, as low magnitudes lead to more meaningful dimensionality reduction. In the last step, the PCA with two components was run, and parameters were adjusted to obtain the highest variance explained with the least number of components.

3.3.5 Correlation Analysis

This part aimed to understand the most influential factors for safety perception on a neighborhood scale. In the crowdsourced platform, users had specific options to choose from. The surrounding infrastructure is known to be important for the perception of safety. This is why an in-depth correlation between infrastructure and safety was investigated.

As some literature indicates [47],[48], the main concerns regarding infrastructure are safety relating to road traffic, such as “unsafe driving practices, poor design and maintenance, poor or no traffic signals and signage, poor roadway lighting, high pedestrian volume and mix and high vehicle volumes/speeds.”

As additional data arose, the Open Data Portal of Barcelona [49] and the Open Street Map [50] service were incorporated to check the possibility of obtaining desired datasets. It was found that the city does not share data on lighting poles, the street width is very specific to every street, and the overall average of the neighborhood needs to capture the complexity. In the end, a broader approach to infrastructure was adopted, as shown in the literature [51], and the following datasets were chosen. As the data collection took place in 2024, the datasets' year of origin should be as up-to-date as possible to avoid losing its relevance. The datasets, format, source, and some features are listed in Table 5.

Table 5: Additional data incorporation with its features and source. Source: Created by the author.

Dataset name	Year of origin	Dataset Format	Administrative level	Source
Administrative boundaries	2024	.shp	District sections	Open Street Map
Administrative boundaries	2019	.shp	Neighborhoods	Open Data Portal
Population	2023	.csv	District Section	Open Data Portal
Density	2021	.csv	District Section	Open Data Portal
Income	2019	.csv	District Section	Open Data Portal
Incidents	2023	.csv	District Section	Open Data Portal
Bike lanes	2022	.shp	Barcelona	Open Data Portal

Dwelling size	2024	.csv	Neighborhood	Open Data Portal
Building age	2024	.csv	Neighborhood	Open Data Portal
Convenience stores	2024	.shp	Barcelona	Open Street Map
Restaurants	2024	.shp	Barcelona	Open Street Map
Bus stops	2024	.shp	Barcelona	Open Street Map

In the beginning, the datasets for the administrative divisions were obtained. The dataset for district sections was fetched using Python's library osmnx using the tag "admin_level:10". The data for neighborhoods were downloaded from the open data portal. Similarly, the other datasets were retrieved by downloading from the portal or fetching through the Open Street Map. The tags used for fetching were: "shop: convenience," "amenity: restaurant," and "highway: bus_stop."

The year of origin differs across the datasets. However, there is only a five-year difference between the oldest and the most up-to-date datasets, which is considered insignificant. Additionally, some datasets, like population or income, do not need a yearly update as they remain the same over several years. The dataset that is most sensitive regarding the year of origin is Bike lanes, as every year, the number of bike lanes increases significantly in Barcelona. The latest version of this dataset was released in 2022, which still makes it acceptable for analysis.

One of the challenges in adding more data to the dataset of the crowdsourced pins was merging them despite differences at the administrative level. As the feeling of safety is usually experienced locally and local indicators influence it, the lowest administrative level of the neighborhood (Seccio Censal) was chosen to perform most of the analysis.

The pipeline for merging was first to perform the spatial join, then grouping and summing the desired variables by the neighborhood's code. The unique codes were assigned by joining the district (Barrio) and neighborhood columns (Seccio Censal). The last step was to merge the data into the dataset with administrative polygons.

Several datasets required some additional data preprocessing, such as bike lanes. The first step in handling this dataset was calculating each bike lane's length in meters, summing them up, and grouping them by neighborhoods. This helped assess each neighborhood's bike lane coverage concerning its area.

	BARRI	SEC_CENS	Code	geometry	Nom_districte	Nom_barri
0	1	1	1:1	POLYGON ((2.17575 41.37827, 2.17577 41.37823, ...	Ciutat Vella	el Raval
1	1	10	1:10	POLYGON ((2.16876 41.37918, 2.16877 41.37918, ...	Ciutat Vella	el Raval
2	1	11	1:11	POLYGON ((2.16744 41.38031, 2.16768 41.38010, ...	Ciutat Vella	el Raval
3	1	12	1:12	POLYGON ((2.16506 41.37981, 2.16517 41.37968, ...	Ciutat Vella	el Raval
4	1	19	1:19	POLYGON ((2.17196 41.38268, 2.17241 41.38215, ...	Ciutat Vella	el Raval

Edat_mitjana	Sup_mitjana_m2	Total_Bike_Lane_Length	safe	unsafe	amenity	shop	public_transport
98.4	76.7	4147.365092	0.0	1.0	10	0	10
130.0	55.2	1829.405919	0.0	2.0	6	0	1
142.1	52.9	2934.926261	0.0	2.0	11	4	0
110.2	56.4	854.612507	0.0	2.0	2	2	1
145.0	64.5	4844.021204	0.0	2.0	25	0	1

Figure 13: Example of observations and the attributes in the final geodata frame. Source: Created by the author.

As a result of this process, a geodata frame with the neighborhoods' geometry and the number of safe and unsafe pins in each neighborhood, alongside additional data, is presented in Figure 13. In the end, a matrix of correlations between safety and numerical variables was plotted. For the matrix, the following datasets were used: building age, dwelling size, bike lane coverage, number of restaurants, number of shops, and number of bus stops.

4 Results and Discussion

This chapter explains the outcomes of the results gathered through the study. The discussion consists of analyzing the crowdsourced data with correlations to gender, space and infrastructure. The findings from the interviews complement the insights from the data. The collected data is sufficient to run the presented analysis; however, more explicit conclusions could only be presented under a larger sample size.

4.1 Crowdsourced Platform

One of the significant factors in performing this analysis was the number of submissions made. One hundred ten submissions were collected in three weeks, with 44 marked as safe spots and 66 as unsafe. This close-to-even distribution was sufficient to determine some of the most important patterns.

Figure 14: Number of submissions for gender and safety. Source: Created by the author.

The gender perspective presented in Figure 14 shows that more points were submitted by women (72) than men (38). However, men tend to pay more attention to unsafe areas, as 71% of the pins submitted were 'unsafe.' Women, on the other hand, submitted almost equal numbers of unsafe and safe pins (54% and 46%, respectively).

The study also aimed to estimate the willingness to share sensitive data on safety and fear. This was validated positively as people and women were especially surprised that "finally someone is doing something about it." At platform promotion events, many people expressed that such platforms are essential as they help them feel heard. Even if the users did not get an instant value added from submissions, they still wanted to do that and believed the information would be helpful. The users felt the need to use the platform, and some empowerment was attached. With such positive responses from the users and supporters, it is safe to say that the platform passed the test on user-friendliness and need-finding.

4.2 Gender Perspective

One of the questions to be answered by the data is what men and women fear the most in public spaces. The next question is if anything else is not included in the reasons users would like to express under the open text input 'Other.' The results were very concrete, with one factor prevailing and the rest on approximately the same level. The option 'Other' was used once without filling in the text input. This may indicate that the factors were chosen correctly and that people could convey the message through the form.

The results presented in Figure 15 indicate that for both men and women, the most frequent reason for feeling unsafe in public spaces is by far intimidating people around. According to the interviews, women are scared of drunk-looking males, especially when they are in groups. The coping tactics are not dragging attention, avoiding eye contact, or calling a friend or partner. The situation changes, however, when another woman is present in the space. This finding corresponds with insights from [32] that state that women feel more comfortable in a space when they see someone looking alike regarding age, ethnicity, etc.

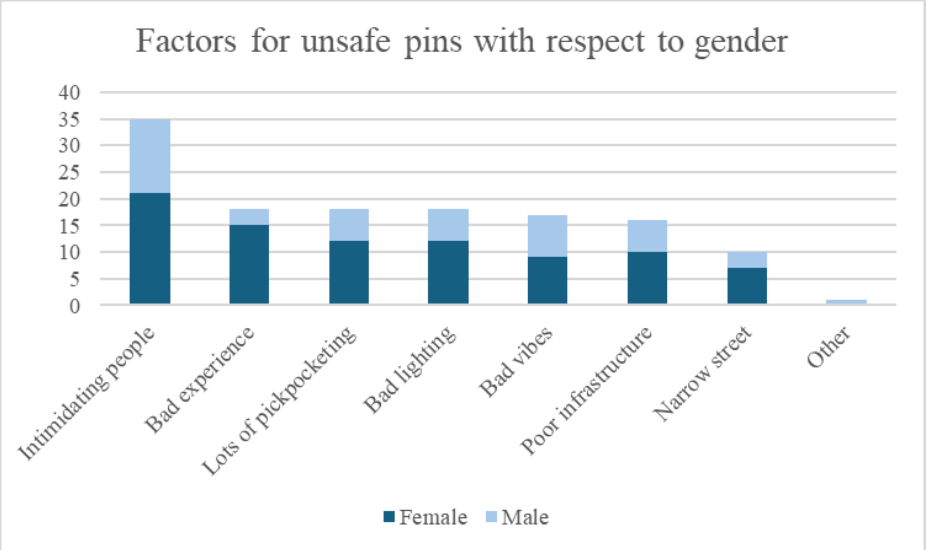

Figure 15: Factors for unsafe pins with respect to gender. Source: created by the author.

The second reason for women to feel unsafe is a bad experience. This corresponds not only to the experiences they have personally gone through but also the experiences of their close circle. If something seen as bad happened to their sister or best female friend, they are much more likely to adopt a wrong opinion about the place. When it comes to men, the second most common reason is bad vibes. This is particularly tricky since 'bad vibes' are commonly understood and felt, but the definition is vague. This study's interpretation is based on the interviews and would be a combination of unpleasant factors such as deserted areas, poor infrastructure, and intimidating people.

The remaining factors, such as pickpocketing, lousy lighting, and poor infrastructure, had a similar overall sum. The narrow street reason was chosen the least number of times,

indicating minor relevance. Overall, the infrastructure-related factors have a lower impact on feeling unsafe.

As Figure 16 shows, the results of safe places were much more unified regarding the reasoning. Regarding safety perception, the infrastructure played a more significant role as women chose wide streets the most frequently. The second most important factor was the many people around, which correlates with the reason for intimidating people around as a negative factor. The reason most frequently chosen by man was good vibes, which again is not self-explanatory. Incorporating the interview knowledge, good vibes are understood as a place with many people, good infrastructure, and amenities such as restaurants or bars.

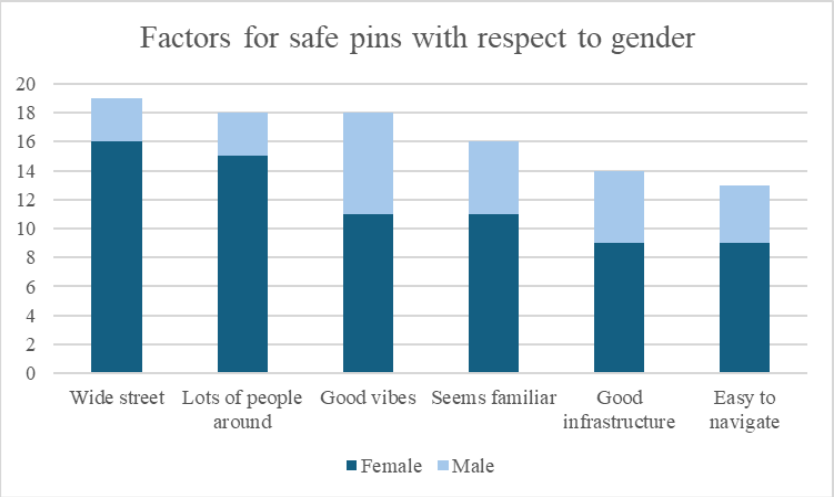

Figure 16: Factors for safe pins with respect to gender. Source: created by the author.

The two least frequently picked reasons are good infrastructure and easy to navigate. During the interviews, the ease of navigation played an essential role in whether or not people perceived specific spaces as nice and welcoming. However, the difficulty in navigation may not impact the feeling of safety to a great extent.

4.3 Spatial Distribution

One of the important aspects of the analysis was how the unsafe pins were distributed among the districts. The smallest administrative division of the city was chosen to visualize it on the map. The 110 pins were distributed among 78 neighborhoods. Figure 17 presents the Kernel Density Function for safe pins on the left side and unsafe pins on the right side.

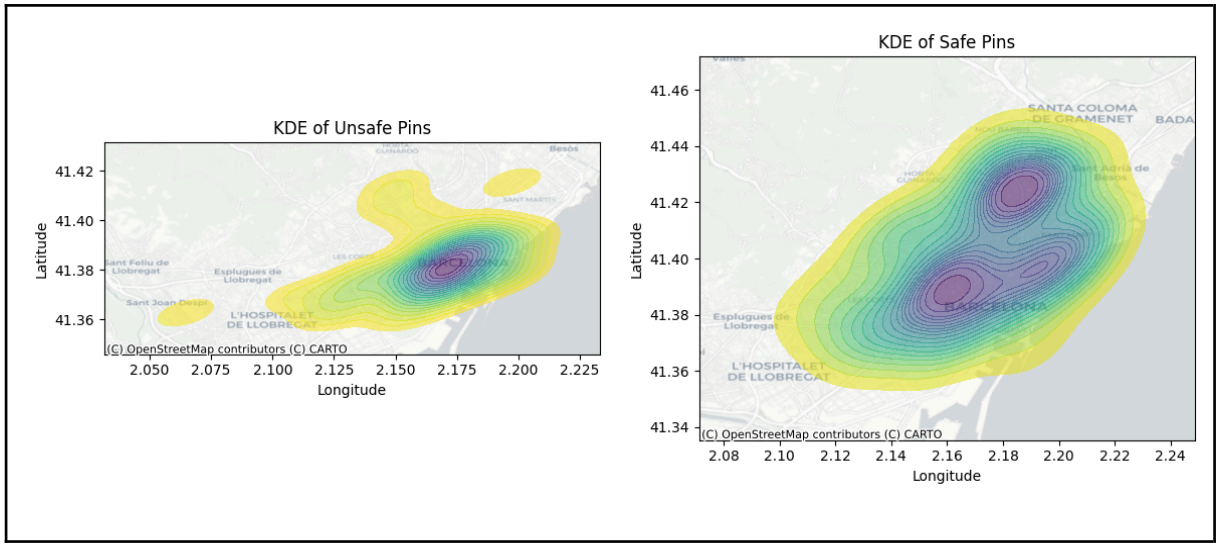

Figure 17: Kernel Density Function for safe and unsafe pins. Source: Created by the author.

It can be observed that unsafe pins have some more even distribution among the city, with their concentration in the city center and some island-like observations on the north and inland. Regarding the safe pins, they are more spread around the city, with three epicenters in the north, south, and seaside areas. The patterns in the distributions are very distinct, and some larger datasets should be incorporated to draw unambiguous conclusions.

A more detailed investigation was conducted for the distribution of the unsafe pins. Figure 18 shows that the district with the most unsafe pins is el Poble Sec, marked in yellow on the map on the left.

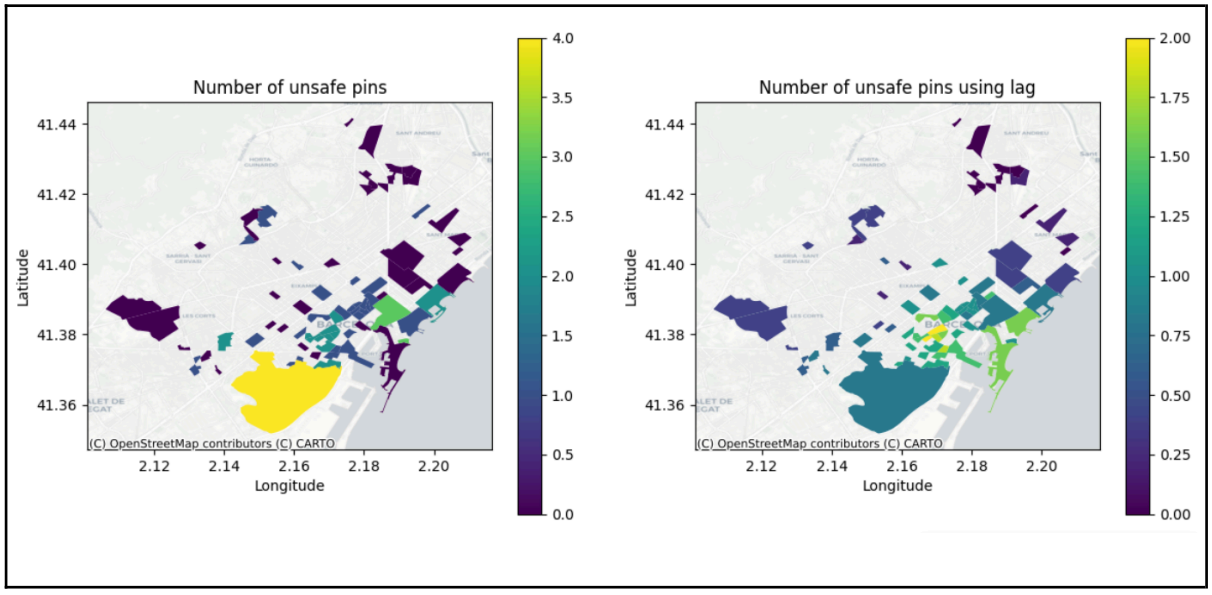

Figure 18: Number of pins per district and number of pins according to lag operator. Source: Created by the author.

Since this interpretation of the results creates biases regarding the area, the spatial lags were used to capture the variable's local context. After applying spatial weights through the spatial lag operator, there is a noticeable difference in the intensity of observations. The epicenter shifted to the city center, with the highest lag in the Ciutat Vella, specifically the el Raval

district. This correlates with the information from the interviews where people indicated el Raval as the least safe district in Barcelona, with the highest crime rates recorded in most years since 2011.

4.4 Principal Component Analysis

The Principal Component Analysis was conducted to reveal some patterns in the data. Figure 19 shows several groups of observations clustered together. The observations spanning up to 0 in the x-axis, marked in purple, could correlate with unsafe pins. The unsafe pins had some more distinct patterns regarding reasons for feeling unsafe. The safe pins could be clustered together on the right-hand side of the graph, marked in orange.

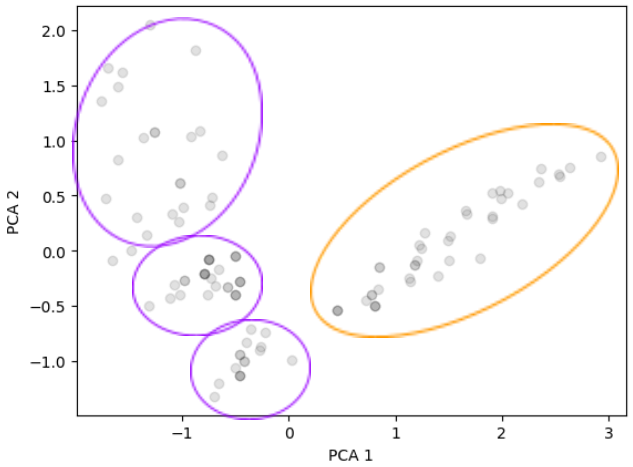

Figure 19: Principal Component Analysis. Source: Created by the author.

The behavior of the clusters observed in PCA may indicate that the safe and unsafe pins follow some different characteristics. The distances between those characteristics are big enough to create clusters. This observation confirms the previous conclusions from spatial distribution and gender perspective. However, these two components explained only 42% of the variance, which could be more satisfactory considering the dataset's size. Four components explained 56% of the dataset's variance, which is considerably better and indicates a higher analysis quality.

4.5 Additional Data

Incorporating additional data was necessary to understand if the analysis made common sense and followed some greater spatial patterns. Three datasets of socio-economic statistics and one regarding incidents are shown in Figure 20 and Figure 21. The administrative divisions for these datasets are district sections. As seen on the first map, the population of Barcelona is highly concentrated in the middle of the city and on the southwest boundary. This suggests a high autocorrelation as the further away from those district sections, the lower the population. The pattern is very different in terms of the density of the population. The high-density sections are instead concentrated in the middle of the city, but no clear pattern can be

observed. The south and north boundary sections prove to have the lowest densities. It can be observed that in the central sections, the high population overlaps with the high density.

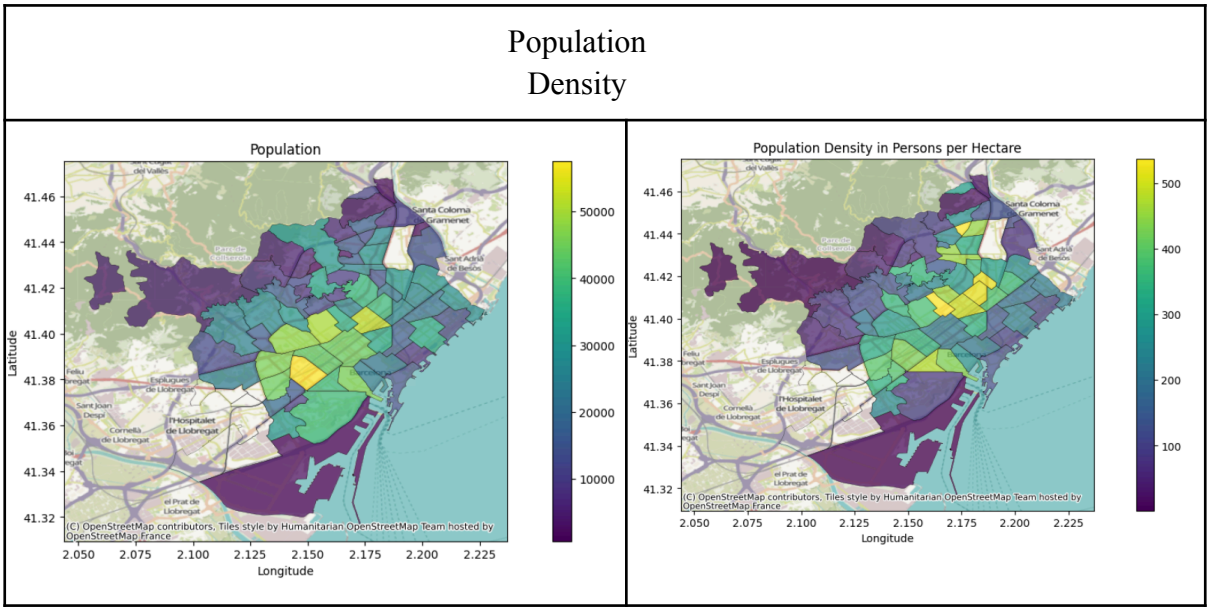

Figure 20: Maps of population in 2023 on the left and population density [per./ha.] in 2021 on the right in Barcelona for district sections. Source: Created by the author based on Barcelona Open Data Portal data [49].

Figure 21 presents the datasets for income in euros per year and number incidents. The patterns for both datasets are rather distinct. The most concentrated areas of high income are in the western sections of the city, covering the districts Sarria-Sant Gervasi and the northern part of the district Les Corts. Additionally, some sections in the district of PobleNou, close to the sea, are characterized by upper intermediate income. The lowest income groups are located in the southern part of the seaside, the northern bordering districts, and the old town Ciutat Vella, especially the el Raval section.

Regarding the reported incidents, the highest number is in El Raval, which is in the old town district. The second most affected section is part of the Eixample district. These findings confirm the statistics from Chapter 1.2.1 on crime rates in Barcelona, where the Ciutat Vella and Eixample were the two districts with the highest crime rates. The sections located to the south, la Marina del Prat Vermell, and northwest sections, such as Sarria-Sant Gervasi, have the lowest intensity of incidents in Barcelona. In the district Sarria-Sant Gervasi, some negative correlation could occur between income. The patterns observed in the incidents and density maps indicate a positive correlation between the number of incidents and density.

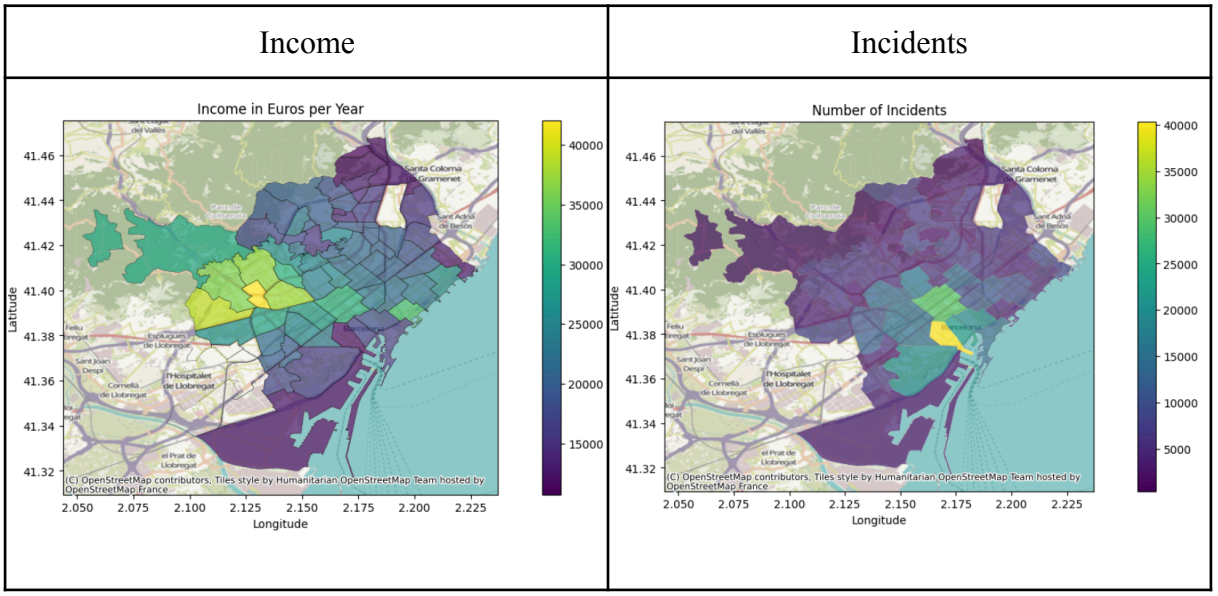

Figure 21: Maps of income [eur./year] in 2019 on the left and number of incidents in 2023 on the right in Barcelona for district sections. Source: Created by the author based on the Barcelona Open Data Portal data [49].

The datasets on infrastructure are presented in Figure 22 and correspond to the dwelling size in square meters, building age in years, and bike lane coverage in meters. These datasets are presented on maps divided into neighborhoods, a lower level of the administrative division. Dwelling size, building age, and bike lane coverage could directly influence the feeling of safety, and the minimal administrative division could greatly support the local context.

In the map presenting the dwelling size, it can be observed that there is a higher intensity of big dwellings in the city's western neighborhoods and across the diagonal axis. On the other hand, the smallest dwellings are located in the south section of el Poble-Sec and the west part of Sarria-Sant Gervasi. This district was associated with one of the highest incomes in Barcelona. However, this pattern does not correlate directly with the dwelling sizes as this district's color range is big.

When it comes to the buildings' age, it could be noticed that the buildings with bigger ages could be found in the old town district covering the sections of el Raval or el Gotico. The newest settlements are located further up north in the industrial district of PobleNou, which is currently undergoing a significant repurposing of residential areas.

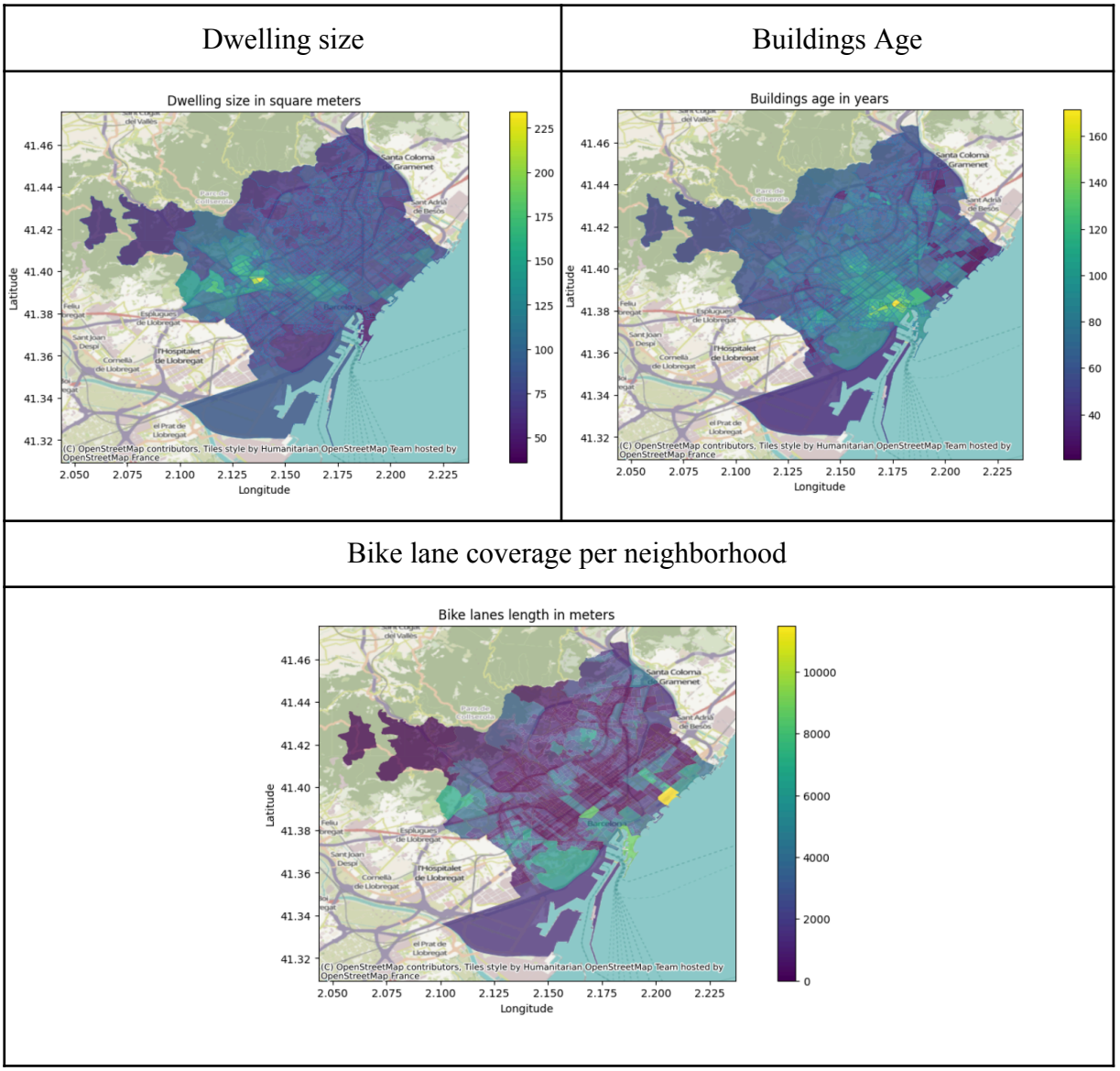

Figure 22: Maps of dwelling size [m2] top left, building age [years] top right, in 2024, and bike lane coverage [m] at the bottom in 2022 in Barcelona for neighborhoods. Source: Created by the author based on the Barcelona Open Data Portal data [49] .

As Figure 22 suggests, the hotspots of high bike intensity are scattered around the city without a noticeable pattern. The interpretation of this variable depends much on the local context of the sections. In some, there is pacified road traffic, which technically is not a bike lane but makes it much easier for bikes to move. In other cases, especially in the old town, the roads are mostly one-way and do not have space for an additional lane for bikes. However, the bike and pedestrian-friendly speed limits of 10 and 30 km/h were introduced in this case.

On the other hand, the coverage is much lower in the outskirts, probably due to the peaceful road traffic that makes coexistence with bikes possible. Nevertheless, the section with the highest coverage is close to the seaside and is part of the PobleNou district. This is likely because many new developments in that district promote active mobility and thus have a decent number of bike lanes.

4.6 Correlation Analysis

The matrix of correlations in Figure 23 presents the influence variables have on each other. It shows a strong relationship between building age and safety, as safe and unsafe factors equal -0.43 and 0.45, respectively. This means the higher the building age, the less safe it feels. This correlates to the earlier insights that the old town, possibly having the highest building age, has the highest crime rates. As one of the factors for feeling unsafe is bad experiences, and it has significant importance, it can be concluded that the old town feels the least safe. However, whether or not it depends on the building age and architecture needs further investigation as narrow streets as a factor for unsafe did not get much importance.

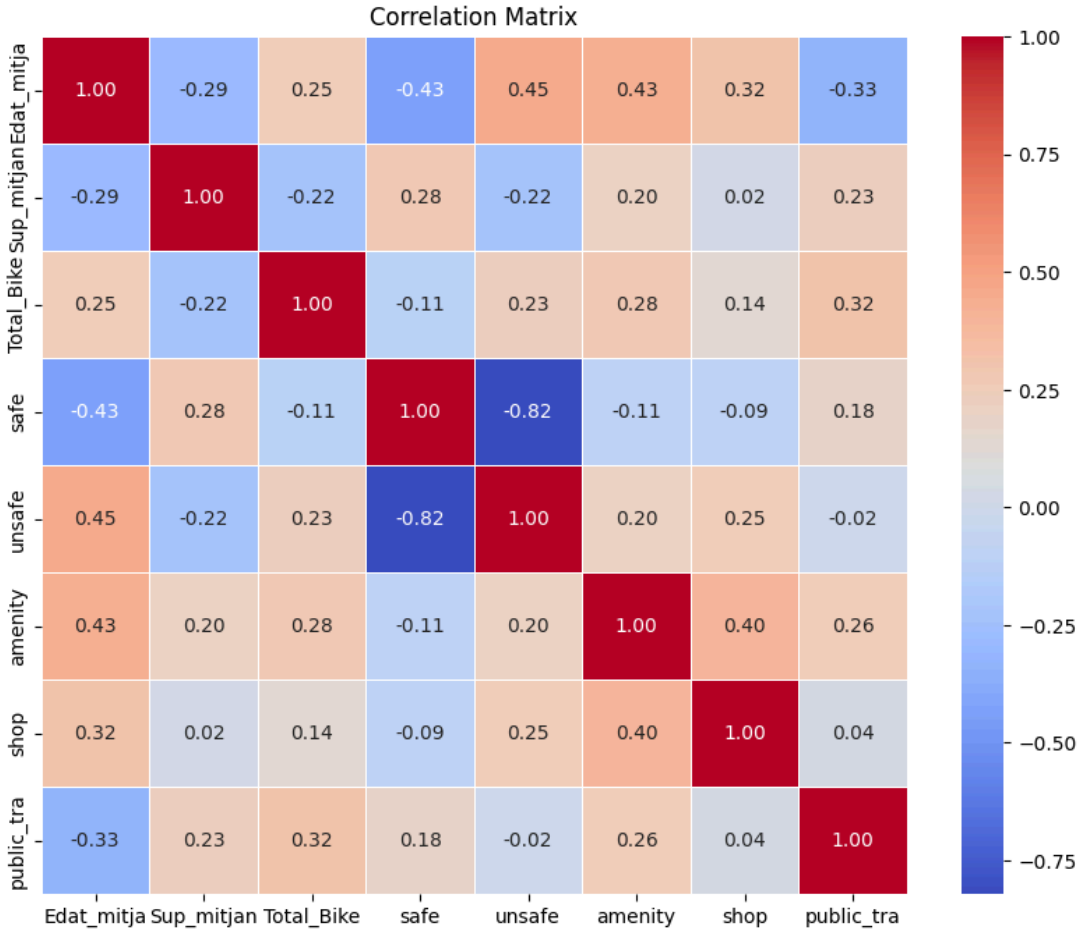

Figure 23: Correlation matrix between additional variables. Source: Created by the author.

There is also a positive correlation between building age and the number of restaurants (0.43) and restaurants and shops (0.40). This indicates that the old town, the most popular tourist region, has the most restaurants and shops. Another high correlation is observed between a building's age and dwelling size, suggesting that the higher the building's age, the lower the dwelling size. The places with the highest building age are likely to influence the number of bus stops negatively. This might be because of the old town's pacified, one-way, narrow streets. The correlations below 30% were discarded as insignificant.

The building's age proves to be the most influential factor for many variables. This can lead to the conclusion that the old town has many different characteristics from the rest of the districts that greatly influence the feeling of safety. According to the study, the reason for that is a combination of bad experiences and intimidating people.

5 Conclusions

Exploring safety perception in urban mobility sheds light on the complex dynamics between technology, infrastructure, and human behavior. In urban mobility, safety dictates how people interact with city services. This study confirms that the interaction happens in various ways and often depends on gender. The women's travel behavior considers safety, convenience, and household situation. Women prioritize safe routes and are willing to sacrifice time in the fear of unwanted, often sexual, contact, especially at night. The problem is even more so if trips are made with the children. On average, women are still primary caregivers for their families, and they often make chain trips to places like shopping or picking up kids on their way home.

Cities worldwide have made various efforts to accommodate the needs of women in urban mobility. Much work is still necessary to successfully address the needs regarding safety. The perception of safety is very subjective and significantly depends on one's experiences; thus, launching dedicated services is a meticulous process. The importance of interviews while tackling perception problems must be emphasized. A sense of safety is highly personal, and surveys or forms cannot capture its essence. Interviewing people is time-consuming and requires advanced soft skills; however, a conversation is key to getting to the bottom of the problem. Many learnings from this study are impossible to show in numbers and tables, as feelings are not quantifiable.

However, this does not change the fact that continuous work is needed to improve women's sense of safety and benefit society. This work provides some guidance on successfully conducting a dialog with vulnerable groups in the city. The application developed in this study proved to be an excellent first step in understanding the safety shortcomings. People happily interacted with the application, and the data collected resulted in solid results. The study shows that for both men and women, the most important factor for feeling unsafe was by far 'intimidating people around.' Regarding safety factors, women most often indicated 'lots of people around ' and 'wide street,' indicating that infrastructure plays a significant role in safety perception. Men tend to lean more towards 'good vibes,' which should be investigated further what good vibes mean for them.

This study confirms that Barcelona's old town is a particular example of a lack of safety. According to the platform, this district has the highest number of unsafe pins. This finding is aligned with the literature review and statistics presented in this thesis. Various analyses were made to understand what is the root cause. The findings indicate that urban structure and infrastructure have some negative influences, and the data collected partially confirms that. Many responses pinpointed that it is people who make it feel so unsafe. This would highlight socio-economic challenges together with the lack of infrastructural investments.

This thesis work provides the workflow for crowdsourced data analysis considering open data. The main limitation of the analysis originates from the amount of data gathered and open data availability. Thus, future development should concentrate on increasing the volume of data. To achieve that, the application should offer more value added to the user. Firstly, the data gathered should also be shared on the platform. This can encourage users to treat the

platform like a place with reviews where they can check and interact with other people's reviews. Secondly, a full-fledged marketing campaign in collaboration with the city should be organized to ensure that the platform is widely recognizable and that word-of-mouth marketing starts working. Additionally, mobile-friendly features should be added to the platform to improve users' satisfaction with the service. The suggested work is passed on to Your Way Home and will be implemented by the company.

References

[1] Macmillan R, Nierobisz A, Welsh S. Experiencing the Streets: Harassment and Perceptions of Safety among Women. *Journal of Research in Crime and Delinquency*. Epub ahead of print 1 August 2000. DOI: 10.1177/0022427800037003003.

[2] Howard J. Sexual Assault & Harassment. *Canadian Women's Foundation*, https://canadianwomen.org/the-facts/sexual-assault-harassment/ (2017, accessed 8 May 2024).

[3] Haskell L, Randall M. *The Impact of Trauma on Adult Sexual Assault Victims*, https://www.justice.gc.ca/eng/rp-pr/jr/trauma/index.html (10 January 2017, accessed 8 May 2024).

[4] EpData. Estadística del crimen en Adeje, https://www.epdata.es/crimen-asesinatos-robos-secuestros-otros-delitos-registrados-cada-municipio/6 (2023, accessed 10 May 2024).

[5] Idescat. El municipi en xifres, https://www.idescat.cat/emex/?id=080193&lang=en (accessed 11 May 2024).

[6] Ortiz A, Marga P. Barcelona in numbers: Tourism, between wealth and residents' complaints. *Barcelona Metropolis*, https://www.barcelona.cat/metropolis/en/contents/tourism-between-wealth-and-residents-complaints (2019, accessed 12 May 2024).

[7] Barcelona, Spain - Intercultural City. *Intercultural cities programme*, https://www.coe.int/en/web/interculturalcities/barcelona (accessed 11 May 2024).

[8] Territory - Territori - Àrea Metropolitana de Barcelona. *Territori*, https://www.amb.cat/web/territori (accessed 11 May 2024).

[9] Ortiz A, Marga P. Barcelona in numbers: crimes, victims and safety. *Barcelona Metropolis*, https://www.barcelona.cat/metropolis/en/contents/barcelona-numbers-crimes-victims-and-safety (2019, accessed 11 May 2024).

[10] The Hospital Clínic closes 2023 treating 678 sexual assaults in the A&E Department. *Clínic Barcelona*, https://www.clinicbarcelona.org/en/news/the-hospital-clinic-closes-2023-treating-678-sexual-assaults-in-the-a-e-department-2-8-more-than-last-year (accessed 11 May 2024).

[11] Barcelona victimisation survey. *Safety, Prevention and Coexistence*, https://ajuntament.barcelona.cat/seguretatiprevencio/en/documents/barcelona-victimisation-survey (accessed 10 May 2024).

[12] Bases de datos y gráficas de la Agencia Europa Press, https://www.epdata.es/crimen-asesinatos-robos-secuestros-otros-delitos-registrados-cada-municipio/6 (accessed 11 May 2024).

[13] Mcguckin N, Murakami E. Examining Trip-Chaining Behavior: Comparison of Travel by Men and Women. *Transportation Research Record: Journal of the Transportation Research Board*, https://journals.sagepub.com/doi/10.3141/1693-12 (1999, accessed 11 January 2024).

[14] Understanding How Women Travel Full Report. *Scribd*, https://www.scribd.com/document/426595576/Understanding-How-Women-Travel-Full-Report (accessed 13 May 2024).

[15] Nosal Hoy K, Puławska-Obiedowska S. The Travel Behaviour of Polish Women and Adaptation of Transport Systems to Their Needs. *Sustainability* 2021; 13: 2693.

[16] Chant S, Mcilwaine C. Cities, slums and gender in the global south: towards a feminised urban future by Sylvia Chant and Cathy Mcilwaine, Routledge, 2016, pages 299. *Decisions* 2017; 44: 161–163.

[17] Levy C. Travel choice reframed: 'deep distribution' and gender in urban transport. *Environment and Urbanization* 2013; 47–63.

[18] Melosik Z. *Samochód, tożsamość i płeć kulturowa*. Wydawnictwo Naukowe UAM, http://hdl.handle.net/10593/14216 (2015, accessed 11 May 2024).

[19] Wesselmann ED, Kelly JR. Cat-Calls and Culpability: Investigating the Frequency and Functions of Stranger Harassment. *Sex Roles* 2010; 63: 451–462.

[20] Logan LS. Street Harassment: Current and Promising Avenues for Researchers and Activists. *Sociology Compass* 2015; 9: 196–211.

[21] Condon S, Lieber M, Maillochon F. Feeling unsafe in public places: Understanding women's fears. *Revue française de sociologie* 2007; 48: 101–128.

[22] Kash G. Always on the defensive: The effects of transit sexual assault on travel behavior and experience in Colombia and Bolivia. *Journal of Transport & Health* 2019; 13: 234–246.

[23] Fairchild K, Rudman LA. Everyday Stranger Harassment and Women's Objectification. *Soc Just Res* 2008; 21: 338–357.

[24] Quinones LM. Sexual harassment in public transport in Bogotá. *Transp Res Part A: Policy Pract* 2020; 139: 54–69.

[25] Gardner N, Cui J, Coiacetto E. Harassment on public transport and its impacts on women's travel behaviour. *Australian Planner*. Epub ahead of print 2 January 2017. DOI: 10.1080/07293682.2017.1299189.

[26] Tripathi K, Borrion H, Belur J. Sexual harassment of students on public transport: an exploratory study in Lucknow, India. *Crime Prevention and Community Safety* 2017; 19: 240–250.

[27] Gekoski A, Gray JM, Adler JR, et al. The prevalence and nature of sexual harassment and assault against women and girls on public transport: an international review. *Journal of Criminological Research, Policy and Practice* 2017; 3: 3–16.

[28] Mackett RL, Thoreau R. Transport, social exclusion and health. *Journal of Transport & Health* 2015; 2: 610–617.

[29] Boniface S, Scantlebury R, Watkins SJ, et al. Health implications of transport: Evidence of effects of transport on social interactions. *Journal of Transport and Health* 2015; 2: 441–446.

[30] Moser, Caroline ON. *Gender, Asset Accumulation and Just Cities: Pathways to transformation*. 1st ed. Routledge, https://www.routledge.com/Gender-Asset-Accumulation-and-Just-Cities-Pathways-to-transformation/Moser/p/book/9781138193536 (2015, accessed 18 January 2024).

[31] Zhu M, Teng R, Wang C, et al. Key environmental factors affecting perceptions of security of night-time walking in neighbourhood streets: A discussion based on fear heat maps. *Journal of Transport & Health* 2023; 32: 101636.

[32] *YourGround Victoria Report*. XYX Lab and CrowdSpot, https://drive.google.com/file/d/1Lhy9GPNpDgUXY_-k_hONTRLENF7a0axG/view?usp=embed_facebook (2021, accessed 28 April 2024).

[33] UN-Women. *SAFE CITIES AND SAFE PUBLIC SPACES FOR WOMEN AND GIRLS GLOBAL FLAGSHIP INITIATIVE: INTERNATIONAL COMPENDIUM OF PRACTICES*. UN-Women, https://www.unwomen.org/sites/default/files/Headquarters/Attachments/Sections/Library/Publications/2019/Safe-cities-and-safe-public-spaces-Compendium-of-practices-en.pdf (2019, accessed 1 May 2024).

[34] UN-Women. *ENSURING SAFE PUBLIC TRANSPORT WITH AND FOR WOMEN AND GIRLS IN PORT MORESBY*. UN-Women, https://unwomen.org.au/wp-content/uploads/2015/12/UNW_safe_public_transport.pdf (2015, accessed 1 May 2024).

[35] Transport Connectivity: A Gender Perspective. *ITF*, https://www.itf-oecd.org/transport-connectivity-gender-perspective (2019, accessed 11 January 2024).

[36] Canada T. 2022-23 Gender Based Analysis Plus (GBA+). *Transport Canada*, https://tc.canada.ca/en/corporate-services/transparency/corporate-management-reporting/departmental-plans/transport-canada-2022-2023-departmental-plan/2022-23-gender-based-analysis-plus-gba (accessed 11 January 2024).

[37] Lyft Launches Women+ Connect, https://www.lyft.com/blog/posts/women-plus-connect (accessed 1 May 2024).

[38] Voi. *Voi*, https://www.voi.com/blog/results-and-recommendations-gender-equity-research (2024, accessed 1 May 2024).

[39] Insua DR, Kersten GE, Rios J, et al. Towards Decision Support for Participatory Democracy. *International Handbooks on Information Systems* 2008; 651–685.

[40] Misra A, Gooze A, Watkins K, et al. Crowdsourcing and Its Application to Transportation Data Collection and Management, https://ledantec.net/wp-content/uploads/2014/09/Misra-et-al-2014-Crowdsourcing.pdf (2014, accessed 28 April 2024).

[41] YourGround. *YourGround*, https://www.yourground.org/ (accessed 11 May 2024).

[42] Levels P. Building a startup in public: from first line of code to frontpage of Reddit. *@levelsio (Pieter Levels)*, https://levels.io/hoodmaps/ (2017, accessed 1 May 2024).

[43] Barcelona Neighborhood Map. *Hoodmaps*, http://hoodmaps.com/barcelona-neighborhood-map (accessed 11 May 2024).

[44] GitHub - htwyford/crowdsourced-map: A simple crowdsourced map that can be run without a server. *GitHub*, https://github.com/htwyford/crowdsourced-map (accessed 11 May 2024).

[45] SOSAFE. Términos y Condiciones. *SOSAFE*, https://www.sosafe.app/en/terminos-y-condiciones.html (accessed 10 May 2024).

[46] OpenAI, https://openai.com.

[47] Hussain MS, Kumari R, Nimesh V, et al. Assessing impact of urban street infrastructure on pedestrian safety perception. *Proc Inst Civ Eng Urban Des Plan* 2021; 174: 76–84.

[48] Peña-García A, Hurtado A, Aguilar-Luzón MC. Impact of public lighting on pedestrians' perception of safety and well-being. *Safety Science* 2015; 78: 142–148.

[49] Open Data BCN, https://opendata-ajuntament.barcelona.cat/es (accessed 10 May 2024).

[50] Query Features. *OpenStreetMap*, https://www.openstreetmap.org/query (accessed 10 May 2024).

[51] Austin DM, Furr LA, Spine M. The effects of neighborhood conditions on perceptions of safety. *Journal of Criminal Justice* 2002; 30: 417–427.

Appendices

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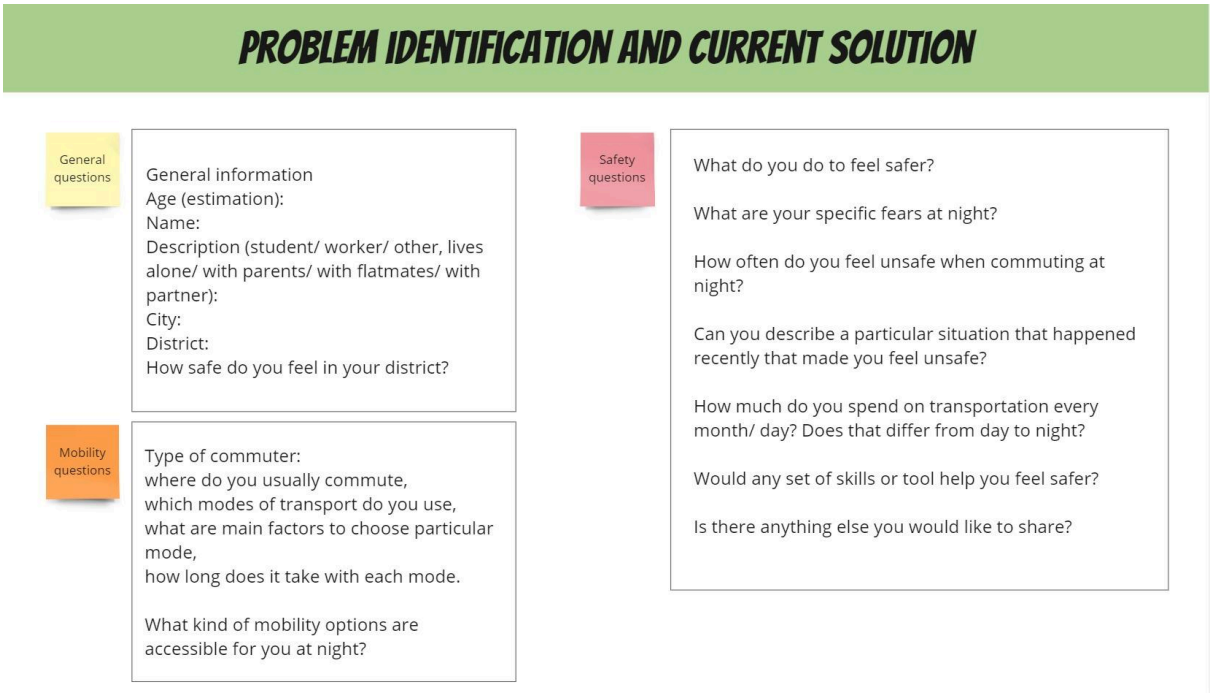
Katarzyna Sowinska
10/05/2024

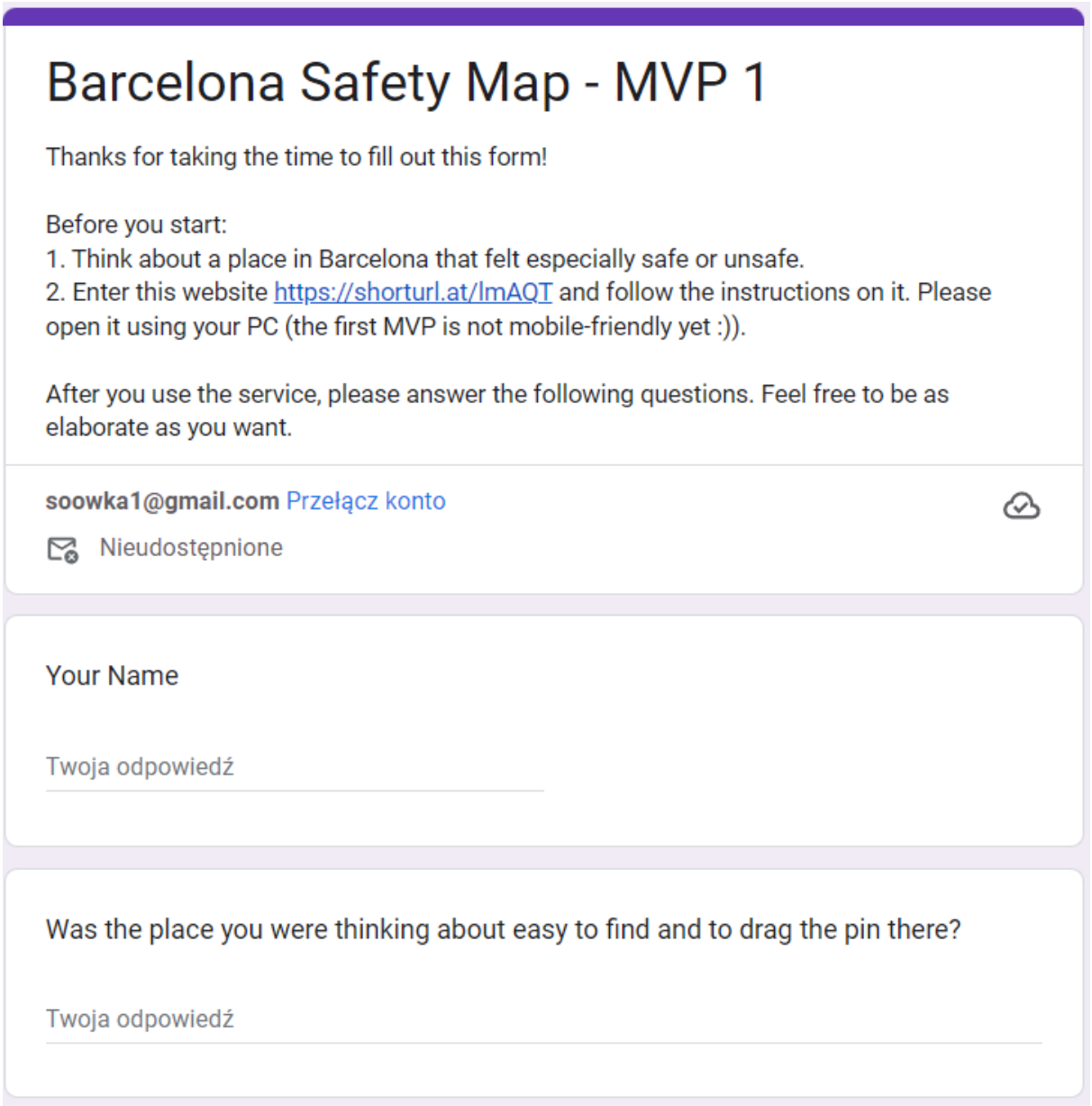
II. Appendix 2

Template of questions asked to people during the interviews regarding safety concerns in Barcelona



III. Appendix 3

Questions asked to users when testing MVP1 and MVP2



Barcelona Safety Map - MVP 1

Thanks for taking the time to fill out this form!

Before you start:
1. Think about a place in Barcelona that felt especially safe or unsafe.
2. Enter this website https://shorturl.at/lmAQT and follow the instructions on it. Please open it using your PC (the first MVP is not mobile-friendly yet :)).

After you use the service, please answer the following questions. Feel free to be as elaborate as you want.

soowka1@gmail.com Przełącz konto

Nieudostępnione

Your Name

Twoja odpowiedź

Was the place you were thinking about easy to find and to drag the pin there?

Twoja odpowiedź

Was the reason for the places being safe or unsafe included in the comments section?

Twoja odpowiedź

What was the main difficulty in using the service?

Twoja odpowiedź

Is there anything else you would like to share?

Twoja odpowiedź