Doctoral Thesis in Urban and Regional Planning

To Catch Fear In A Bottle

Conceptualizing and Measuring Perceived Safety in Urban Environments

JONATAN ABRAHAM

KTH ROYAL INSTITUTE OF TECHNOLOGY

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Abstract

Cities are complex, dynamic and constantly evolving systems, shaped by a plethora of factors that in turn significantly impact our individual safety. These factors are embedded in everything from the physical design of urban settings to the social interactions and activities that take place within them. Compared to other urban challenges such as crime, perceived safety and fear are more abstract and subjective phenomena that are much more difficult to define, understand and not to mention prevent. The aim of this thesis is to examine how perceived safety can be conceptualized and measured in urban environments in order to enhance the accuracy and comprehensiveness of urban safety diagnostics. The approaches of the studies explore both more traditional methods of surveys, regression models and spatial analysis, as well as more emergent methodologies of the past few decades, such as deep learning models and mobile app data collection. The studies include analyses of perceived safety on multiple levels, from meso- to micro-level, comparisons of residents and non-residents, as well as intersectional analyses of gender, age, ethnicity, and income. The findings of the thesis highlight how various conceptualizations of perceived safety and methodologies used to measure them reveal different understandings. Local and global measures of fear have inverted relationships with marginalized men in Sweden, who, in contrast to common beliefs, express similar levels of poor neighborhood safety to women overall. Spatial and conceptual contrasts were identified between survey-based measures of neighborhood safety, objective safety measures such as crime rates, and safety scores generated by deep learning models. A survey based on a public participation geographic information system (PPGIS) revealed the moderating effect of place familiarity and place stigma, where minor differences in neighborhood familiarity were found to significantly affect perceptions. Mobile app data collection was also found to be a potential way to capture highly spatio-temporally detailed data on perceived safety, while retaining the ability to capture personal narratives and emotional connections to place. The thesis concludes with a reflection of implications and practical insights of the findings for researchers, urban planners, and policymakers, encouraging strategies for more comprehensive diagnostics of safety.

Keywords
Urban safety, spatial analysis, GeoAI, territorial stigma, participatory mapping.

Sammanfattning

Städer är komplexa, dynamiska och ständigt föränderliga system, formade av en mängd olika faktorer som i sin tur har en betydande inverkan på vår individuella trygghet. Dessa faktorer är inbäddade i allt från den fysiska utformningen av urbana miljöer till de sociala interaktioner och aktiviteter som äger rum inom dem. Jämfört med andra urbana utmaningar såsom brottslighet är upplevd trygghet och rädsla mer abstrakta och subjektiva fenomen som är mycket svårare att definiera, förstå och inte minst att förebygga. Syftet med denna avhandling är att undersöka hur upplevd trygghet kan konceptualiseras samt mätas i urbana miljöer för att förbättra träffsäkerheten och omfattningen av trygghetsdiagnostik i städer. Angreppssätten i de inkluderade studierna omfattar både mer traditionella metoder såsom enkäter, regressionsmodeller och geografiska analyser, men även nyare metoder från de senaste decennierna såsom djupinlärningsmodeller (deep learning-modeller) och datainsamling via mobilapplikationer. Studierna inkluderar analyser av trygghet på flera nivåer, från meso- till mikronivå, jämförelser mellan boende och icke-boende, samt intersektionella analyser av kön, ålder, etnicitet och inkomst. Avhandlingens resultat belyser hur olika konceptualiseringar av upplevd trygghet och de metoder som används för att mäta dem ger upphov till olika förståelser. Lokala och globala mått på rädsla visade omvända samband för marginaliserade män i Sverige, vilka uttrycker – i motsats till rådande uppfattningar – liknande nivåer av otrygghet i sina bostadsområden som kvinnor i stort. Geografiska och konceptuella kontraster identifierades mellan enkätbaserade mått på trygghet i bostadsområden, objektiva säkerhetsmått såsom brottsstatistik, samt trygghetspoäng genererade av djupinlärningsmodeller. En enkät baserad på PPGIS (Participatory Public Geographic Information System) visade på den modererande effekten av platsbekantskap och platsrelaterad stigma, där små skillnader i kännedom om området hade stor påverkan på trygghetsuppfattningen. Datainsamling med hjälp av en mobilapplikation visade också potential att fånga in mycket detaljrik rumslig och tidsmässig data om upplevd trygghet, samtidigt som den möjliggör insamling av personliga berättelser och känslomässiga band till platsen. Avhandlingen avslutas med en reflektion kring implikationer och praktiska insikter av resultaten för forskare, stadsplanerare och beslutsfattare, med en uppmaning till strategier för mer heltäckande trygghetsdiagnostik.

Nyckelord
Urban trygghet, rumslig analys, GeoAI, territorial stigma, deltagarstyrd kartläggning

Preface

At the time of writing, I have been connected to KTH for 12 years - as a university student, research assistant, and now PhD candidate. I began my journey at KTH as an engineering student, since I'd long had an affinity for STEM subjects. Yet my deeper interests have always gravitated more toward social justice and social sustainability, particularly the exclusionary processes that affect certain societal groups. Luckily, I found a meaningful intersection in urban planning, where I learned to explore the spatial dimensions of social issues, such as accessibility, segregation, and - most significantly - safety.

I deepened my interest in the spatial realities of safety through my work with Vania Ceccato, my PhD and master's supervisor, with whom I co-authored several publications on *rural* crime and fear. Though I didn't know it at the time, this research introduced key questions that would come to define my future thesis work. For one, key issues within rural criminology include how "rural" should be defined, as well as how crime and safety can operate and be measured differently across contexts. Second, it sparked my interest in the relational nature of safety, i.e., the emotional and symbolic meanings of place. Over time, research became more appealing than working in professional practice. When the opportunity arose to continue researching safety as part of a PhD, I gladly accepted.

However, my PhD-trajectory was never straightforward or predictable. I began as a licentiate student on a 2-year project in the aftermath of the first few waves of Covid-19, not knowing whether I would continue toward a full doctorate. The project was part of the newly launched Senseable Stockholm Lab, a collaboration between MIT, KTH and Stockholm City, where we were to explore the use of deep learning models to generate safety perception maps of Stockholm. Though methodology was rather unfamiliar to me, its novelty quickly drew me in. Early on, however, we recognized that we needed to establish *what* exactly we were measuring. While the project progressed and would eventually lead to several publications (two included in this thesis), it wasn't clear at that point if my work was enough for a licentiate, let alone a PhD. In parallel, Vania suggested we turn our eyes to the gendered nature of fear and safety, focusing on men's fear, shaping the first paper of the thesis. I was somewhat familiar with the role of masculinities in safety from our work within rural criminology. At the same time, we further considered the effect of different operationalizations of fear and safety, including crime worry and neighborhood safety perceptions.

The Stockholm Senseable lab project continued together with Digital Futures, and I was no longer aiming for a licentiate degree, but a full PhD. While my studies were now spanning urban perceived safety in multiple ways, a common conceptual thread of the

thesis was not fully established until the final project. The project produced two papers focused on the stigmatized district of Järva, each providing relatively new methodology (PPGIS and mobile app surveys, respectively). Once more, they differed in how we measured and conceptualized safety, from comparative perspectives of different city-users to real-time youth safety perceptions. At this point, I recognized that the thesis could not only rely on the methodological novelties of the papers, but the conceptual considerations needed for each method were of equal importance. The title's phrase "To catch fear in a bottle" is a play on the idiom "to catch lightning in a bottle", reflecting both the methodological and conceptual challenges of capturing something as abstract and elusive as perceived safety and fear. This is especially true in urban contexts, as cities embody multiple layers of meaning: functional, emotional, symbolic, and socio-cultural, which deeply shape how safety is experienced, expressed, and studied.

Given the thesis's varied, interdisciplinary, and at times even controversial topics, I feel it is important to not only reflect on my own positionality as a researcher, but also as an individual shaped by personal experience. My background has two potential relevant implications for how I relate to the work presented here. First, I am a 30-year-old man (at the time of writing), born in Sweden to East African immigrant parents. As a man, I recognize that I am shaped by various hierarchical social structures, particularly those related to masculinity and race/ethnicity. While I identify as a feminist, or ally, I am aware that I am not exempt from the influence of gendered conditioning of society, especially on the gender-related topics found in this thesis. At the same time, my experience as a minority has given me some insight into systems of oppression, which could enhance my sensitivity to these issues. This duality is especially relevant in the first paper, where the intersection of my identity as a minority man and my engagement with feminist theory shaped my interpretation and analysis. Second, I did not grow up in Stockholm, but in Eskilstuna in the stigmatized neighborhood of Fröslunda, which is similar in reputation to Järva. Growing up aware of how others perceived my home and myself, I can relate and empathize with Järva residents, particularly the youth, which has undoubtedly influenced my analysis in papers IV and V. My background heightens my sensitivity to the risk of reinforcing negative stereotypes through my work, which I have attempted to address through critically engaging dominant narratives and media portrayals of Järva, while remaining committed to present empirical findings transparently, even when they may be uncomfortable.

These facts also make this thesis all the more personal and meaningful to me. While my relationship with the work has, at times, been a "love-hate" one, I am ultimately happy that I chose this path and that I am now at the end of it. At the time of writing, I am unsure if academia will be my long-term home, but I will always be grateful for the time I have spent under its roof.

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I owe many intellectual and emotional debts to a range of people who supported me throughout my PhD journey. First and foremost, I would like to thank my supervisor, Vania Ceccato, for her guidance, feedback, extraordinary patience, and for always going above and beyond to support me throughout my PhD (and before). You've undeniably pushed my growth as a researcher, and I will always be grateful for that. Second, I would like to give thanks to my co-supervisor, Per Näsman, whose teaching and guidance helped me gain a fundamental grasp of the statistical methods that have underlined my main methodology of analysis in the thesis. I would also like to give appreciation to my many co-authors and colleagues within the Senseable Stockholm Lab. Thank you, Fabio Duarte, Yuhao Kang, Lukas Ljungqvist, Song Gao, Fan Zhang and Carlo Ratti, as working with you all was a delightful and valuable learning experience. I also thank all the other people I met at both MIT, Stockholm Municipality, and KTH through this collaboration, who are all valued but are too numerous to list here.

At several steps throughout my PhD, there were a number of individuals who directly helped me formulate and improve upon my thesis. Thank you, Charlotta Thodelius, for being the discussant at my licentiate start-up seminar, providing valuable feedback and important queries to resolve early on. Thank you, Martin Andresen, for doing the same at my PhD mid-seminar, and Ute Besenecker for giving extensive feedback, suggestions, and insights at my final seminar. Thank you, Karin Bradley, for conducting the internal review of the thesis and resulting feedback, which helped me ensure it was up to the standards of KTH.

I would like to give special thanks to my colleagues at the ABE-school and specifically the URS-division. Most importantly, thank you, Jacob and Ioannis. I believe we will always be bonded from what we endured together as PhD-students. Our traditional lunches at "Q" were something I always looked forward to and I am sure it gave me the motivation needed to complete my studies. Thank you also to Devika, Elise, Eskil, Hanna, Karin, Harriet, Mikael, Emma, and Rebecka, and all other PhD-students for contributing to such a warm, inspiring, and fun environment to engage with one another in. As a fellow member of the Urban and Community Safety Research group, I thank you Gabriel; as I feel we have both grown and learned from each other as researchers. I also want to give special thanks to the administration of ABE during my time, including Therese I., Therese G., Betty, Mia, and Sofia, for their support and answers to my stupid questions the past four years. And thanks to all other colleagues I haven't mentioned: during these four years, no matter how difficult or stressful my PhD could be, I will always cherish that I got to know so many of you wonderful individuals.

I of course have a special place for my friends and family. I am blessed that there are many of you, but I am also cursed as a result, as I cannot name all of you here, nor can I truly express my full gratitude. However, I would like to particularly mention Criss and CJ for being my gym buddies, as well as joining as players together with German and Fabian in our Call of Cthulhu-sessions; you all helped me maintain both my physical and mental health during my studies. I also have a number of family friends who have supported me not only during my PhD but throughout most of my life, including Genet, Tigist, Helena, and Yeshimabet, including their families, but also many more.

I would also need another essay to name and thank all my of my family and relatives. I would like to say particular thanks to Teddy, Lilish, Selam, Helen, Yonas, and Melat not only for being amazing people, but also for showing me around and letting me stay with them whenever I visited conferences in the United States. Finally, I want to thank my parents, Elizabeth and Abraham, for raising me to value academics, always pushing me to do my best, and supporting me when I was down. I hope to pay you back someday. I want to thank Sara for being the best, supportive little sister one could ask for. And last, but the opposite of least, I need to thank my fiancé Rosanna. Like safety, my love and gratitude for you may not be easily measured, but I will spend my life showing it to you.

List of publications

Paper I:

Men's fear in public places: a Scandinavian case study

Abraham, J. Ceccato, V. Näsman, P. Under review in *Cities*.

Paper II:

Assessing Differences In Safety Perceptions Using GeoAI And Survey Across Neighbourhoods In Stockholm, Sweden (2023).

Kang, Y. Abraham, J. Ceccato, V. Duarte, F. Gao, S. Ljungqvist, L. Zhang, F. Näsman, P. Ratti, C. Landscape and Urban Planning 236 (2023)

DOI: https://doi.org/10.1016/j.landurbplan.2023.104768

Paper III:

Crime And Visually Perceived Safety Of The Built Environment: A Deep Learning Approach (2025).

Abraham, J. Kang, Y. Ceccato, V. Näsman, P. Duarte, F. Gao, S. Ljungqvist, L. Zhang, F. Ratti, C. Annals of the American Association of Geographers, 1–21.

DOI: https://doi.org/10.1080/24694452.2025.2501998

Paper IV:

From Locals To Outsiders: A Comparative Analysis of Neighborhood Safety Perceptions

Abraham, J. Ceccato, V. Näsman, P. Under review in *Nordic Journal of Criminology*.

Paper V:

Urban Safety in the Eyes of the Youth: A Mobile App Study of Swedish Adolescents in a Stigmatized Neighborhood

Abraham, J. Ceccato, V. Näsman, P. Taha Ali. Submitted to *Children's Geography*

Publications not included in this thesis

What Makes a Place Safe? Assessing AI-Generated Safety Perception Scores Using Stockholm's Street View Images (2025)

Ceccato, V. Kang, Y. Abraham, J. Näsman, P. Duarte, F. Gao, S. Ljungqvist, L. Zhang, F. Ratti, C.

The British Journal of Criminology, 2025

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CONTENTS

1 Introduction

In the age of globalization and rapid social change, ensuring safety has become more essential than ever. To both be and feel safe is a fundamental component of a sustainable city (UN-Habitat, 2012; United Nations, 2015), where the publicness of its public spaces depends on them also being perceived as safe (Ceccato and Nalla, 2020). Poor safety perceptions in society may lead to collective distrust and division within communities and can be exploited politically to implement divisive policies and practices (Hale, 1996; Jackson and Gray, 2010; Kapust, 2008). At an individual level, research has long shown that beyond just emotional distress, poor perceived safety may also greatly impact or restrict people's health, lifestyle and behavior (Moore and Trojanowicz, 1988; Gray et al., 2011; Hale, 1996; Jackson and Gouseti, 2012; Miethe, 1995). In the city of Stockholm, the capital of Sweden, combatting poor perceived safety has become one of the main priorities of the municipality since 2020 (Stockholm Stad, 2022)

Despite its recognition as a critical urban challenge, the complexities of individual safety perceptions remain unresolved. For instance, there is yet no consensus on how to even define and properly conceptualize safety. While crime is a major source of urban insecurity, fear of crime is often conflated with perceived safety despite evidence that they are distinct (Hinkle, 2015). Research shows no consistent link between actual crime risk and perceived safety nor fear of crime; crime hotspots are not always seen as unsafe, while areas with few crimes may still be avoided and perceived as unsafe (Ceccato and Newton, 2025). Unlike objective safety (indicated by the actual risk of danger), perceived safety is largely subjective in nature and varies across a range of different types of city users – notably influenced by e.g. age, gender, ethnicity, sexuality, and personal experiences, as well as the intersection of these characteristics (Ceccato and Nalla, 2020; Crenshaw, 2013; Hale, 1996). This is also what largely constitutes one's *dispositional fear* (individual fear propensity in different contexts), whereas *situational* fear is more dependent on immediate environmental conditions (Gabriel and Greve, 2003), two commonly conflated concepts. Urban characteristics (including physical design, disorder and vibrancy) are often more important explaining neighborhood safety than actual crime levels (Skogan, 1986; Wilson and Kelling, 1982; Wood et al., 2008). As such, safety depends not only on actual risk but also on psychological, social, cultural, and spatio-temporal factors, and demands a comprehensive understanding to be fully addressed.

Given its multidimensional nature, much of research is dedicated to identifying methodologies to properly quantify and measure safety perceptions. The conventional

methods include surveys or interviews, which are often time- and resource-consuming, often limiting studies to small-scale analyses or low spatial resolution. Emerging methodologies such as deep learning models have opened up new possibilities, both in terms of the scale of the data processing and the type of data that can be analyzed. In combination with the increasing availability of Big Data sources like street view images and crowdsourced data enable new, spatiotemporally detailed methods for measuring urban safety. But even here (or perhaps more so) the consideration of *what* dimension of safety is measured is essential to make use of these methodologies.

The aim of this thesis is to examine how perceived safety can be conceptualized and measured in urban environments in order to enhance the accuracy and comprehensiveness of urban safety diagnostics. The approaches of the appended research papers explore both more traditional methods of surveys, regression models, and spatial statistics, as well as more emergent methodologies of the past few decades, such as deep learning models and data collection through mobile applications. The studies include analyses of safety perceptions on multiple levels and perspectives: from meso- to micro-level safety perceptions, comparisons of residents and non-residents, as well as intersectional analyses of gender, age, ethnicity, and income.

The objectives of the thesis are to:

1. Obtain a better understanding of the nature of fear and safety in urban environments in the context of Stockholm, Sweden

2. Identify feasible ways to measure and compare different conceptualizations of perceived urban safety, as well as objective risk indicators such as crime.

3. Investigate how individual and contextual factors are related to perceived safety and how poor safety may impact individual behavior.

4. Assess how social and emotional ties to places, such as place attachment, familiarity and place stigma, moderate safety perceptions.

5. Formulate recommendations for governance and planning bodies to better enhance urban safety through policy interventions, spatial planning, and community engagement strategies.

The thesis is constituted by the cover essay summarizing the research, followed by the papers that were produced (Paper I-V). The essay includes a theoretical background highlighting key concepts and how the thesis is positioned within relevant fields of research. A conceptual framework for how the thesis engages with urban safety

perceptions is presented, including how each paper contributes to the framework. The methodology and data used in each study are then described, followed by a summary of the individual papers. The essay finishes with a wider discussion of the findings and their implication for research and practice, concluding with recommendations for policy and concluding remarks.

2 Theoretical background

2.1 Understanding safety and fear: conceptual challenges

The ambiguity and contested nature of safety and fear remain central to both theoretical and empirical discussions in this thesis. The lack of a universal definition is not merely a semantic issue but reflects deeper disciplinary differences in how safety and fear are approached, measured, and addressed in practice.

Across fields, the term *safety* takes on varied meanings. In criminology it is often linked to the risk of victimization or exposure to crime (Hale, 1996); in risk assessment, it concerns the probability of measurable hazards (Khan et al., 2015; Renn, 1998); and in public health, it can relate to control of hazards and diseases, but also the mental and physical consequences of fear (Maurice et al., 1997; Sampson and Morenoff, 2000). At its most generalized form, it refers to some presence of security and absence of worry, fear or risk. Yet rather than converging on a universal meaning, these perspectives emphasizes different causes, consequences, and units of analysis. Researchers often make the distinction between *objective* safety (more commonly referred to as *security)*, which involves the empirical likelihood or risk of, e.g. being injured or becoming a victim of crime, and *perceived* safety, which consists of a collective of emotional fears, worries and perceived likelihood of risk. In this thesis, perceived safety is the central concept and will generally be used as an umbrella term encompassing various fears and anxieties related to urban life, yet commonly discussed in a criminological and/or urban planning context. However, as the theoretical review will reveal, this is a far from obvious or universally agreed-upon conceptualization.

Most efforts to define fear at its most basic form typically include one or more of the following elements: (1) an intense negative emotional state, (2) triggered by specific stimuli (e.g., actual or potential threats), (3) accompanied by various defensive responses, whether physiological or behavioral (see e.g., Fisher, 2012; Warr, 2000; Mobbs et al., 2019). Above all, the primal function of fear is to alert of the presence of danger or harmful threat, whether that threat is grounded in reality or not. In urban contexts, a common source of fear is crime. Within criminology, the term *fear of crime* has been an established social scientific concept since the 1960s, where both statistical and theoretical investigations undertaken on the subject have helped legitimize its research relevance (Jarrett-Luck, 2015; Hale, 1996). Similar to the general fear concept, there is no strict consensus on the definition of fear of crime. It is generally described as “an emotional reaction of dread or anxiety to crime or symbols that a person associates with crime” (Ferraro, 1995: p. 23). However, it has long been understood to

be a complex amalgamation of personal experiences and social and emotional ties, operating at individual, neighborhood and macro-level (Gerber et al., 2010; Ceccato, 2012). Fear of crime is largely thought to be embedded in broader anxieties of social and cultural change and tensions (Ceccato, 2012; Taylor 1995), and, therefore, can neither be understood as a strictly static nor isolated phenomenon but rather as evolving along-side society.

At an individual level, demographic factors such as age, gender, socioeconomic status, influence people's propensity and expression of fear. Fear of crime has been perceived as an irrational response to crime events, as many times the least victimized are those who tend to report higher levels of fear – most notably women and elderly (see "the fear paradox", Koskela, 1999; Garofalo, 1979; Stafford and Galle, 1984; Warr, 1984). While having been previously victimized is a consistent predictor of fear, actual crime rates are rarely well-represented by fear levels reported by the public. The reasons for these are manifold. For one, some individuals or groups may perceive themselves to be more vulnerable in terms of their ability to escape or fend off offenders. It may also be the result of improper selections of measurements of fear of crime, but it also hints at the role of socialization, cultural narratives and spatial constraints in shaping fear responses. This also further highlights the difficulty of disentangling it as a whole from other phenomena. For instance, this thesis will generally refer to fear of crime and *worry* of crime as interchangeable. Yet many researchers make the distinctions between expressive fear (linked to general beliefs and concerns about victimization) and experiential fear (fear as a direct experience) (Farrall et al., 2009; Engström and Kronkvist, 2022). This is similar to the dichotomization of *dispositional* and *situational* factors of fear (Gabriel and Greve, 2003); often described as *fear as a trait* (dependent on your individual propensity to express fear) and *fear as a state* (dependent on spatiotemporal conditions and events taking place). While distinct, these two dimensions are highly interlinked and influence each other. High dispositional fear can influence the likelihood of certain situations evoking fear. Individual relationships with place can affect both situational and dispositional fear. A setting can evoke or reduce fear based on how familiar it is (Lorenc et al., 2013; Traunmueller et al., 2016), its functionality (e.g., a park versus commercial area)(Ceccato and Snickars, 2000), the time of day it is experienced (day versus night time) (Boessen et al., 2017), and the social composition of those who are present (e.g. neighbors versus strangers)(Lupton, 1999).

Fear and safety are evidently contextually and socially constructed concepts, meaning that they may require dynamic understandings that consider what constitutes modern anxieties, the nature of victimization, as well as the socio-spatial relationships between people and places. Social and political narratives surrounding safety has evidently been impacted by war and immigration trends over the world, especially emphasizing the

racialized elements of fear (Waters and Kasinitz, 2015; Martinez et al., 2021). The Covid-19 pandemic and post-era has shifted general routine activities (e.g. from on-site to increased remote and hybrid work and education), affecting the interaction between potential offenders, victims and guardians (Johnson and Nikolovska, 2022; Ceccato et al., 2022b). Much of the legitimacy of legacy news media in the last decade has been hollowed out with the shift of news distribution to internet and social media, including how information on crime and other sources of fear and worry is shared (Ardia et al., 2020; Näsi et al., 2021; Shahrad, 2024). The rise of AI has provided both opportunities in crime prevention and research, as well as new sources of insecurities, bias, and possible avenues for new types of offenses and anxieties surrounding them (Gerritsen, 2020). As these changes reshape social landscapes, understanding fear and safety requires adaptable frameworks that reflect evolving technological, social, and spatial realities.

2.2 The link between fear and crime in urban environments

Although fear, perceived safety, and crime are deeply interconnected in public discourse, empirical research has long shown that their relationships are not always straightforward or proportional. For example, despite a significant decline in crime rates over the past two decades in several countries, both fear of crime and poor neighborhood safety perceptions have remained persistently high (Van Dijk et al., 2012; Rader, 2017). The perception of crime levels also rarely matches up with actual crime statistics, with several individuals believing crime is increasing despite evidence to the contrary (Skogan, 1986). Nevertheless, there are some commonalities in the conditions and processes that drive these phenomena, even if their relationship is not always direct or proportional. Most notably, while both crime and fear research have long had a dispositional bias (Solymosi et al., 2018; Ekblom, 1995), it is often by studying contextual factors that one finds their intersections. Neither crime nor fear occur randomly across space and time but are influenced by various dynamics and attributes linked to place. The research subfields of community criminology, focusing on the role of broader neighborhood factors of crime, and environmental criminology, which focuses on the situational factors causing crime opportunities, offer several theories that will help build the conceptual framework of this thesis.

Neighborhood disorder, referring to the perceived lack of order and community social control, is one of the key factors influencing both crime and safety perceptions (Skogan, 1992). Order and control are determined by visible cues - both physical and social cues - perceivable by residents (Ross and Jang, 2000). Social disorder consists of public anti-social behaviors that signal danger, including substance use, street altercations, or even just the visible presence of certain groups (e.g., male adolescents). Physical disorder

refers the visible conditions of the neighborhood, in terms of cleanliness, level of maintenance *Social disorganization theory* (Shaw and McKay, 1942) explains how neighborhood level factors such as poverty, residential instability, and ethnic heterogeneity can make neighborhoods more vulnerable to disorder and, by extension, crime. Social disorder can particularly erode *social cohesion* - a measure of strengths of relationships and sense of connectedness within communities (Forrest and Kearns, 2001) – and *collective efficacy* – referencing the shared willingness of residents to intervene for the common good (Sampson et al., 1997). Both social cohesion and collective efficacy have been linked to lower crime rates, as communities with strong networks and mutual expectations can reduce crime more effectively than formal policing alone (Browning et al., 2004). Furthermore, strong social ties can act as a buffer against the effects of living in areas characterized by crime and disorder, reducing fear and mistrust (Ross and Jang, 2000). When people trust and feel connected with their neighbors they are more likely to interpret ambiguous situations as less threatening, contributing to an overall sense of safety.

The link between neighborhood disorder, crime and safety is often encapsulated by the Broken Windows Theory (Wilson and Kelling, 1982) which argues that visible signs of physical and social disorder signal a breakdown in informal social control, potentially inviting further antisocial behavior and elicit fear. However, the theory has been widely debated, where even the link between crime and disorder overall has been scrutinized (Sampson and Raudenbush, 2004; Gau and Pratt, 2008; Weisburd et al., 2023; Ren et al., 2022). On the other hand, several studies, including in European contexts, continue to show that disorder strongly influences both crime and perceptions of safety (Wikström et al., 1997; Mellgren et al., 2010; Wood et al., 2008). It is important to note that these relationships are often mediated by other factors, such as socioeconomic factors, social cohesion, and collective efficacy (O'Brien et al., 2019; Camacho Doyle et al., 2022). However, in their seminal study, Brunton-Smith and Sturgis (2011) provide a complementary perspective, demonstrating that crime, visible disorder and neighborhood structure affect fear of crime independently, while Camacho Doyle et al. (2022) notes that the relationship also depends on how fear is operationalized.

Calls for greater spatial granularity have led to the growing use of place-based approaches in fear research, including in Sweden (Kronkvist et al., 2025; Solymosi et al., 2015; Guldåker et al., 2024; Pánek et al., 2019), while they longer tradition within criminological research. Environmental criminologists consider the role of urban design, land use functions and individual mobility patterns to explain micro-places of crime. Theories on crime opportunity, such as the *Routine Activity Approach* (Cohen and Felson, 1979) and *Crime Pattern Theory* (Brantingham and Brantingham, 1984), suggest that crime tends to occur in shared activity spaces where offenders and potential victims

interact. Certain land uses, such as commercial areas, bars, and transport hubs, can function as crime attractors, drawing offenders to locations where victims are more accessible (Kinney et al., 2008). Other areas, such as parks and open drug markets, may create environments with fewer guardianship mechanisms, making them more vulnerable to criminal activity (Kinney et al., 2008). Similar types of locations often appear in both perceived safe and unsafe place typologies, with perceptions varying by time of day and the presence of specific activities or social groups (Guldåker et al., 2024; Ceccato et al., 2022a). According to Jacobs (1962), well-designed street layouts and diverse land use can promote natural surveillance, often referred to as 'eyes on the street'. By fostering social activity and pedestrian presence, these design elements help deter crime and enhance perceptions of safety. Similarly, Newman's (1972) concept of defensible space shows how residential design, such as building height, window placement, and territorial boundaries, affects residents' ability to monitor and control shared spaces. This concept laid the foundation for Crime Prevention Through Environmental Design (CPTED) (Cozens et al., 2005), which emphasizes strategies like natural surveillance, access control, improvement of image and territorial reinforcement to reduce crime. Research by Cozens and Sun (2018) found that locations perceived as unsafe often lacked key CPTED principles, such as clear sightlines, appropriate levels of prospect and refuge, and opportunities for surveillance. According to the *theory of prospect and refuge*, specific urban design decisions can make people feel more secure, particularly when the design balances the ability to observe within an environment (prospect) with available escape routes and protective spaces (refuge) (Fisher and Nasar, 1992; Appleton, 1975). Paradoxically, these characteristics may also be exploited by offenders, as refuge may serve as hiding places and prospect can provide a way to be aware of others. Fisher and Nasar (1992) notes in their study that locations with limited prospect for an individual but high level of refuge for potential offenders were perceived as the most unsafe.

Several studies have found overlapping concentrations of crime and safety perceptions linked to certain place types or functions, yet mismatches persists and the relationships are not always linear (Guldåker et al., 2024; Ceccato and Snickars, 2000; Curtis et al., 2014). Hipp et al. (2022) found that increased human activity in a location can initially lead to higher crime rates by creating more opportunities for offenses. Yet, once a certain threshold of pedestrian presence and guardianship is reached, crime risks tend to decrease. Parks and green spaces, for example, can contribute to social cohesion and informal guardianship, making them feel safer while still harboring potential crime risks due to secluded areas that offer refuge for offenders. Some areas may be perceived as safe due to strong perceived social control, even if crime rates remain high,

while others with low crime levels may still feel unsafe due to environmental design and public perceptions.

2.3 Relational geographies of safety: place and social meaning

Perceptions of safety are not determined solely by crime rates or objective features of the built environment. Rather, they are socially constructed and contextually situated, deeply embedded in how people experience, interpret, and relate to space. Scholars across urban studies, human geography, and environmental psychology emphasizes that individuals' relationships to place, shaped by familiarity, emotion, symbolism, and social positioning, play a critical role in shaping whether places feel safe (Zahnow and Tsai, 2021; Dallago et al., 2009; Pain, 2000; Doran and Burgess, 2011; Valentine, 1989). This section briefly outlines key concepts that explain how perceptions of safety are shaped through individual relationships with place.

Familiarity of place has been found to be one of the stronger influences on perceived safety (Traunmueller et al., 2016). Environments that are regularly used or personally known tend to feel less threatening, as they reduce uncertainty and foster a sense of predictability and sense of control (Valentine, 1990). Familiar places are often perceived as safer precisely because they are known**,** where one feels oriented and confident navigating the surroundings. Unfamiliar settings can in contrast, make you feel lost and disoriented, lose a sense of control, and cause fear (Day et al., 2003). Importantly, this fear can also be socially conditioned; unfamiliar neighborhoods, especially those associated with minority or low-income populations, may be perceived as more dangerous due to racial or class-based prejudice. Yet familiarity is not always protective. Familiar settings may still evoke fear if they are associated with personal trauma, past victimization, or repeated exposure to secondhand accounts of danger (Lupton, 1999). Thus, while familiarity can provide a sense of safety, it can also intensify fear when tied to emotionally charged memories or negative local narratives.

Place attachment refers to the emotional and psychological bonds individuals form with specific environments, often shaped by routine, memory, and identity (Hidalgo and Hernandez, 2001; Lewicka, 2011). Such attachments can act as a buffer against fear, reinforcing feelings of control, belonging, and trust in a place. Residents with strong place attachment tend to report higher levels of neighborhood satisfaction and lower levels of fear, as their connection to place enhances a sense of familiarity and predictability (Kullberg et al., 2009). Slightly more diffuse and transient concept, *topophilia* describes how some environments evoke a more immediate emotional affinity or sensory pleasure (Tuan, 1990). This concept highlights the aesthetic and symbolic qualities of place that make it feel comforting, beautiful, or meaningful.

Topophilia can arise from cultural familiarity, visual consistency, or the presence of nature, and contributes to a sense of safety by generating affection toward space.

In contrast to place attachment and familiarity**,** *place stigma* refers to the negative symbolic meanings assigned to particular neighborhoods or urban areas. These meanings are often shaped less by direct experience and more by broader social narratives, reputational cues, and media portrayals. Without familiarity or firsthand knowledge of a place, individuals often rely on place reputation as a cognitive shortcut when assessing safety (Suttles, 1972; Wileden, 2022). As Valentine (1990) notes, these reputations are frequently built on assumptions about the social composition or perceived character of a place's inhabitants. The media plays a central role in constructing and amplifying these reputations. Through selective storytelling, repeated imagery, and narrative framing, media portrayals can reinforce negative stereotypes of neighborhoods, particularly those associated with ethnic minorities or low-income populations (Shahrad, 2024; Ilovan and Markuszewska, 2022). When a neighborhood is consistently depicted as dangerous or decaying, it contributes to territorial stigmatization—a process in which both outsiders and residents can internalize negative images of place (Haynes et al., 2013; Wacquant, 2007). For residents, this may result in lowered self-esteem, reduced trust in institutions, and diminished socioeconomic opportunities (Permentier et al., 2008; Wacquant, 2008). For non-residents, it may provoke avoidance behaviors, either due to perceived risk or a desire to avoid stigma by association (Oittinen et al., 2024).

Naturally, familiarity, attachment and stigma all depend on the individual's positionality in regards to the location. Residents, for instance, typically possess experiential knowledge of an area's rhythms and social life, which can foster attachment and a sense of control. In contrast, non-residents often lack the same experiential reference points and may base their assessments on generalized images or second-hand narratives (Permentier et al., 2008). Frequent visitors (such as commuters) occupy a more intermediate position. While not fully residents they may still develop a degree of spatial familiarity and emotional connection to place, yet their experiences are often more transient or purpose-driven (i.e. getting to work). This may on the one hand allow them to develop place attachment but still leave them vulnerable to broader reputational narratives and stigma (Lewicka, 2011; Oittinen et al., 2024). These insider-outsider dynamics have not yet been fully explored in research, but can involve, e.g. on-campus and off-campus students' perceptions (Onat and Sahin, 2017), or locals' versus tourists' perceptions (Ergun and Yirmibeşoğlu, 2016; Zou and Mawby, 2021). (Kronkvist, 2022), found in their study that determinants of poor safety were different depending on if one assessed one's own neighborhood compared to other parts of the city.

2.4 The impacts of fear and poor safety

Perhaps the fundamental reason why the research presented in this thesis is relevant to study is that the impacts of fear and poor safety are as multifaceted as the concepts themselves. The consequences can apply to an individual or meso-macro level, shaping not only personal well-being and daily behaviors but also broader social dynamics and urban inequalities.

Individual level

The main reason criminologists gained increased interest in fear of crime during the 1960s was the understanding that the consequences go beyond just a sense of dread towards becoming victimized, but also impact the quality of life, health, and behavior of individuals and communities (Moore and Trojanowicz, 1988; Gray et al., 2011; Hale, 1996). Behavioral responses in individuals toward fear of crime appear to generally fall into four categories (Miethe, 1995; Jackson and Gouseti, 2012).

- Avoidance behavior - e.g. avoiding perceived crime hotspots, minimizing contact with certain people
- Protective behavior - e.g. investing in crime prevention measures, travelling in groups
- Behavioral and lifestyle adjustments - e.g. withdrawing from nighttime activities, avoiding use of public transport
- Participation in collective activities - e.g. neighborhood watch schemes, support groups.

Fear can thus serve both a functional and dysfunctional role. In moderate forms, it encourages vigilance and protective behaviors that may contribute to personal safety. However, when fear becomes pervasive, it may restrict social participation, limit mobility, and reinforce exclusionary behaviors.

Importantly, fear and its impacts are not evenly distributed across demographic groups. Despite having a lower statistical risk of victimization, women and older adults consistently report higher fear levels than men and younger individuals, leading to greater behavioral restrictions and reduced spatial freedom (Pain, 2001). For women, fear is particularly linked to gendered and sexual violence and harassment, to the extent that this permeates fear of other forms of crime (Ferraro, 1996). Studies have shown that fear greatly shapes how women navigate urban spaces by frequently modifying their behaviors—avoiding walking alone at night, choosing longer but perceived safer routes, or carrying defensive objects—to mitigate risks (Valentine, 1989). This constant negotiation of safety reinforces gendered inequalities in access to public spaces,

limiting independence and exacerbating social exclusion (Day et al., 2003). For the elderly, fear is frequently tied to physical vulnerability, mobility limitations, and a perceived inability to escape or defend themselves (Ceccato and Bamzar, 2016; De Donder et al., 2005). This fear often results in withdrawal from certain activities, particularly those that involve being in public spaces after dark. The consequences of such fear-driven restrictions can be severe, leading to social isolation, decreased mental well-being, and a diminished sense of autonomy (Victor and Scharf, 2005)

In contrast, young people and men, are often more victimized by crime yet historically have reported lower fear levels, following the fear paradox (Koskela, 1999; Garofalo, 1979; Stafford and Galle, 1984; Warr, 1984). However, more recent studies point to both men and youth feeling more fearful for certain types of crime (Brå, 2022; Rader, 2017). It also important to note that both groups experience fear and its impacts in different and often less visible ways. Young people's risk assessments differ from adults (Preto et al., 2016; Walker et al., 2009), and due to their lack of spatial autonomy, poorly perceived environments greatly restricts their use of public space – which often already clashes with the use by adults (Lieberg, 1995; Matthews et al., 1998). Masculine norms may discourage men from expressing fear openly, leading to alternative coping mechanisms such as projecting confidence, avoiding potential threats, or forming group alliances to embolden their won masculinity (Day et al, 2001). Fear of confrontation, particularly with other men, shapes male behavior in public, with avoidance, aggression, or strategic social positioning serving as common responses.

An intersectional perspective reveals that these experiences of fear are also not uniform across distinct groups but are shaped by intersecting social identities such as race, class, and disability. Coined by Crenshaw (1989), intersectionality highlights how multiple forms of oppression - such as sexism and racism - interact to create unique vulnerabilities. For instance, research has shown that women of color often experience heightened fear not only due to gendered violence but also racial discrimination in public spaces, leading to further constraints on mobility and access (Buchanan and Ormerod, 2002; Buchanan and West, 2010). While men are often perceived as appropriators of public spaces, this power is not equally shared by minority men - such as men of color and LGBTQ+ men - who often experience greater fear and vulnerability compared to those with more social privilege (Namaste, 1996; Feagin, 1991; Rader, 2017; Day, 2006). As a result, it is often the most marginalized groups that are already socially disadvantaged that are impacted the most by poor safety. How social identities, power dynamics, and environmental perceptions intersect ultimately shapes who feels safe, where, and under what conditions.

Meso-Macro impact

At the community level, fear and poor feelings of safety have profound effects on social cohesion, neighborhood stability, and economic vitality. High levels of fear can erode trust between neighbors, weakening the informal social bonds that underpin collective efficacy—the ability of communities to work together toward shared goals, including crime prevention (Sampson et al., 1997; Lee and Earnest, 2003). When concerns about crime becomes pervasive, residents may disengage from community activities, avoid public spaces, or hesitate to intervene in local issues, further weakening neighborhood ties (Skogan, 1987; Box et al., 1988). Public spaces such as parks, transit hubs, and pedestrian areas are particularly affected by fear-driven avoidance behaviors. The retreat from public space can produce a positive feedback loop of fear and crime, as the retreat from public space means fewer "eyes on the street" and weaker informal surveillance and social control (Skogan, 1986; Cozens et al., 2005).

Continuous high levels of poor safety may lead to stigmatization processes of entire areas, where society labels them as dangerous in the public eyes, further isolating those who live there and reinforcing negative reputations (Permentier et al., 2008; Haynes et al., 2013; Oittinen et al., 2024; Wacquant, 2008). This stigma can perpetuate cycles of fear and exclusion, as non-residents avoid these neighborhoods, and residents themselves become acutely aware of these labels and may internalize them, limiting their own participation in broader societal activities. Stigmatized areas may also lead to individuals avoiding certain jobs at locations they perceive as unsafe, limiting their own career opportunities and impacting local economies. Employers may also struggle to attract and retain talent in areas with high crime rates or reputations for insecurity, which can hinder regional development (Fisher, 1991; Wilson, 2012).

Fear of crime also shapes mobility patterns and urban planning, influencing the design of cities. One common response to high crime concerns is urban flight, where residents, particularly those with financial means, move away from areas perceived as criminogenic, exacerbating spatial segregation and economic disparities (Cullen and Levitt, 1999; Skogan, 1986; Lee and Earnest, 2003). The rise of gated communities and privatized security measures reflects a growing reliance on exclusionary urban planning strategies, which, while providing a sense of security for some, contribute to broader patterns of social fragmentation and inequality (Blakely and Snyder, 1997; Low, 2004). Beyond shaping social and economic behaviors, fear of crime plays a significant role in political discourse and policy-making. Politicians and media outlets may exploit fear by purposefully amplifying concerns about crime to justify increased policing, surveillance, and punitive policies (Glassner, 2010). This strategy has been particularly effective in contexts where public anxieties about crime are disconnected from actual crime trends,

leading to over-policing and discriminatory law enforcement practices that disproportionately impact marginalized communities (Hough, 2004). The demand for heightened security measures has led to the expansion of surveillance technologies, stop-and-search practices, and zero-tolerance policing strategies (Garland, 2001). While these approaches aim to enhance public safety, they can erode civil liberties, particularly for marginalized groups who are more likely to be targeted by aggressive security policies (Graham, 2011). This creates a feedback loop where heightened policing reinforces fear rather than alleviates it, deepening distrust between communities and law enforcement (Loader, 2013).

2.5 How to measure fear – the challenges and potential with established and emergent methodologies

Measuring safety perceptions and fear in a reliable and accurate way has remained a fundamental challenge in safety research. How do we quantify something so inherently abstract, emotional, and subjective? Unlike crime, which can be naturally quantified through, e.g., police-reported incidents, fear is an intangible experience influenced by both social and physical contextual factors, past experiences, and individual propensity to experience and express fear. It can be especially difficult to accurately reflect underlying psychological states rather than external influences such as media exposure (De Silva, 2023) or social desirability, e.g., causing men to refrain from expressing fear (Sutton and Farrall, 2005). Additionally, there is also the spatio-temporal dimension to consider. While crime events are often linked to a specific time and place, facilitating micro-level spatial analyses (Chainey, 2021; Wesiburd, 2015), spatial data on safety perceptions remain relatively rare. When available, such data are typically linked to respondents' home addresses or neighborhoods (Juan et al., 2010; Houser et al., 2019; Kronkvist, 2024) and thus reflect where people who report fear live, rather than where they actually experience fear (Solymosi et al., 2020). Moreover, emotional responses such as fear can persist over time and extend beyond the immediate context, with individuals experiencing fear from the place to city-wide level, or even across more diffuse scales. This also requires attention to how people relate to space in personal terms: their familiarity with an area, sense of belonging, or disconnection from it, all of which shape how safety is perceived. This dynamic and highly context-dependent nature of fear is a core challenge in measuring safety perceptions. Another challenge refers to what has been discussed previously in the theoretical review: the lack of a universal definition. Or perhaps the issue rather lies in the numerous ways you can operationalize expressions of fear, each of which may reflect distinct experiences (Jackson, 2005; Farrall et al., 2009). It might even be more accurate to say that we "model" fear and safety rather than "measure", as research methods largely rely on indirect proxies of internal subjective experiences. Nonetheless, research has developed several

methodologies offering various approaches to capture different dimensions of fear, yet come with their own limitations and challenges.

Surveys remain the most widely used method for assessing fear of crime and perceived safety (Hart et al., 2022). They provide insight into how different populations experience safety and allow for the examination of related factors. Yet, survey-based research on fear has lacked consistency over time, with no standardized set of items used across studies (Hinkle, 2015). Surveys typically attempt to measure fear through direct and indirect questioning. Direct measures typically ask respondents how fearful they feel in certain situations or locations, while indirect measures infer fear and safety perceptions based on related behaviors, such as avoiding specific areas or changing daily routines (Ferraro and Grange, 1987; Warr, 2000). How you operationalize fear has great implications for what is actually being measured. For example, asking, "How afraid are you of being a victim of crime?" may produce distinct results compared to, "How safe do you feel walking alone at night?" (Hinkle, 2015; Ferraro, 1995). The former implies a specific emotional reaction to crime, whereas the latter may capture a broader sense of insecurity, potentially influenced by non-criminal factors such as urban decay or poor lighting. Several studies have also shown that people tend to overestimate or underestimate their fear depending on how questions are framed or the context in which they are asked (Yang and Hinkle, 2012; Etopio and Berthelot, 2024; Ferraro and Grange, 1987; Farrall and Gadd, 2004). Farrall and Gadd (2004) particularly suggest that scenario-based questions (such as walking alone at night) may reflect cultural norms about vulnerability, thereby inflating fear levels among, e.g., women and the elderly. As a result, it has long been suggested that fear of crime, as an emotional reaction, should be treated as distinct from other concepts such as perceived safety and perceived risk (Skogan, 1981; Farrall et al., 1997; Jackson, 2005). Even when comparing formulations explicitly mentioning crime (e.g., fear vs. worry of crime), differences may persist. To address these challenges, many researchers recommend avoiding single-item measures and instead using multi-item scales to better capture the complexity and nuance of individuals' safety perceptions (Jackson, 2005; Jackson, 2009; Chataway and Hart, 2019).

The retrospective nature of surveys is also a source for recall bias, which occurs when respondents fail to accurately remember or reconstruct past experiences, emotions, or behaviors related to an event that is being asked about in the survey (Yan and Cantor, 2019; Choi and Pak, 2005). In fear of crime research, this can lead to respondents inaccurately attributing their current fear levels to an incident that occurred long ago. For example, a person who was a crime victim years earlier may report experiencing persistent fear but fail to distinguish between their immediate post-victimization fear and their current feelings (Schwarz, 2012; Russo and Roccato, 2010). Respondents may

also recall events that are more vivid rather than mundane more frequently (Warr, 1980). Conventional surveys are often also limited in terms of measuring spatial detail, with most questionnaire-based surveys analyzing at the neighborhood- or coarser levels. Increasingly, alternative approaches have been developed in order to capture the geography of safety perceptions. One such approach is Public Participation Geographic Information Systems (PPGIS), which integrates spatial data with individuals' subjective assessments of safety. Unlike traditional surveys that rely on verbal or numerical responses, PPGIS-surveys allow respondents to map their feelings of fear or safety onto geographic locations, providing spatially explicit data that can be analyzed in conjunction with environmental and crime statistics (Ceccato and Snickars, 2000; Preto et al., 2016; Kyttä et al., 2014; Brown and Kyttä, 2014; Guldåker et al., 2024). This method enhances the granularity of fear measurement by capturing localized variations in perceived safety. PPGIS-surveys also mitigate some forms of recall bias by encouraging respondents to anchor their fear assessments to specific places rather than relying solely on abstract recollections of past experiences (Jankowski et al., 2016). However, challenges remain, including digital literacy barriers, potential biases in participation (e.g., underrepresentation of vulnerable populations), and the inherent subjectivity of spatial fear mapping.

The increasing prevalence of smartphones since the beginning of the last decade has also enabled new methods for measuring perceptions of safety through mobile applications. Mobile apps allow for real-time, location-based data collection, reducing recall bias and providing a more dynamic understanding of the experiential nature of safety (Kronkvist and Engström, 2020; Reis et al., 2014; Solymosi et al., 2020). They allow researchers to study participants immersed in the actual environments they are experiencing, which allows for greater generalizability of the findings (Shiffman et al., 2008). There are few studies that have measured the situational dimension of safety or fear using smartphone apps, with a number of exceptions (Solymosi et al., 2015; Solymosi et al., 2018; Kronkvist and Engström, 2020; Chataway, 2020). These applications typically to prompt users to report their feelings of safety in specific locations or times, thereby generating spatially and temporally rich datasets. Mobile apps are also easily accessible to most of the population, meaning that wider scale analyses are more easily achieved. On the other hand, similar to PPGIS-surveys, there are barriers of digital literacy, but the nature of the data collections also requires continuous user engagement. This could lead to selection bias towards those more familiar with mobile applications (often younger people), while some studies have not experienced issues with more senior participants (Jones et al., 2011).

One of the main challenges of conducting larger-scale analyses of urban safety perceptions lies in the resources needed to both collect and process the necessary

amount of data. Recent advancements in deep learning and the availability of Big Data-sources have provided possible solutions to overcoming these limitations, offering scalable and automated approaches to analyze vast amounts of complex and unstructured data (Perry et al., 2013; Gerritsen, 2020; Gao et al., 2021). While there are numerous approaches that could potentially measure urban safety perceptions, particularly the combination of computer vision techniques and street view images have found success in assessing the influence of street environments on crime and safety perceptions (see e.g., Moreno-Vera et al., 2021; Zhang et al., 2021; Harvey et al., 2015; Hipp et al., 2022; He et al., 2022). While traditional surveys require extensive human labor to collect, process and analyze data, deep learning models can process millions of images and their associated metadata and extract meaningful patterns in a fraction of the time.

Deep learning models have been shown to offer a systematic and scalable method for quantifying perceived safety. Naik et al. (2014) developed a model that used Google Street View images to quantify the "perceived safety" of different urban environments based on human ratings. By training a deep learning model on crowd-sourced safety perceptions, the system was able to generalize and predict safety perceptions in new locations with high accuracy. Similar approaches have been expanded to different urban settings, with researchers analyzing how elements such as street width, vegetation, and architectural style contribute to safety perceptions (Zhang et al., 2021; Moreno-Vera et al., 2021). Despite their potential, there are several challenges associated with using deep learning and big data for safety research. The studies mentioned above measure safety at one point in time and space, which fails to capture other surrounding factors of safety perceptions. Furthermore, while admittedly effective representations of streets, street view images are ultimately only proxies of urban environments and does not fully immerse the respondents. Another issue is the bias in training datasets, as perceptions of safety are often subjective and influenced by cultural and socio-economic factors. If a model is trained on a dataset that reflects the biases of a specific demographic group, it may not generalize well to other populations (Gerritsen, 2020). Transparency is also a concern due the black-box nature often associated with AI methods, which calls for theoretically grounded and spatially explicit modeling approaches (Kang et al., 2023).

In summary, there are several established and emergent quantitative methodologies that can be used to measure fear and perceived safety, yet, due to their limitations, neither can likely capture the full extent of individual safety perceptions on their own.

2.6 Operational definitions and key concepts

Based on the theoretical background, it is evident that the concepts of fear and safety are inherently abstract and contested; an issue this thesis directly explores. Their meanings vary across disciplines and contexts, and are often used interchangeably despite key differences. To ensure consistency across the thesis, Table 1 presents the operational definitions and key concepts used in the cover essay and appended papers. These definitions reflect both theoretical frameworks and how the concepts are applied in empirical analysis. However, some conceptual flexibility has been maintained in the individual papers and when required by disciplinary conventions, source material or contextual emphasis. This is discussed where relevant.

Unless otherwise specified, the term "safety" in this thesis refers to perceived safety—that is, individuals' subjective experiences and feelings of safety—rather than objective risk or a combination of the two. Furthermore, as the thesis is situated at the intersection of criminology, urban studies, and spatial planning, the potential dangers and risks considered are primarily related to crime, fear of crime, and urban disorder rather than environmental hazards or accidental injuries. However, certain studies within the thesis begin to explore safety beyond these boundaries.

Table 1 – The definitions of perceived safety and key concepts as used in the thesis.

Category	Term	Definition (as used in this thesis)
Core concepts of safety and fear	**Perceived safety**	A subjective sense of feeling safe in a given space, influenced by environment, personal experience, and sociocultural context. Serves as an umbrella concept in the thesis, encompassing various forms of fears and anxieties.
	Objective safety	Also referred to as *security* or *actual* safety, representing the empirical likelihood of experiencing harm or danger in a given setting, typically based on crime or accident statistics.
	Fear	An emotional reaction often characterized by anxiety, worry, or dread. In this thesis, it is treated as being encompassed by perceptions of safety, though some critical distinctions are discussed.
	Fear of crime	An emotional reaction—often characterized by anxiety, worry, or dread—triggered by crime or the perception of potential criminal threat. In this thesis, the term is often used interchangeably with *worry of crime*, though some distinctions are discussed.

Typologies/dimensions of safety and fear	**Dispositional fear/safety**	Fear as a trait - an individual's general propensity to feel fear across situations, shaped by stable traits such as gender, age, personal history, and social identity. This form of fear tends to persist over time and across contexts.
	Situational fear/safety	Fear as a state - a fear response triggered by immediate environmental cues or social dynamics, such as being alone in an unfamiliar place at night. This type of fear is context-dependent and more transient than dispositional fear.
	Global fear	A broad, generalized concern or worry about safety in society at large. This may be influenced by media, politics, or cultural discourse and is not necessarily tied to direct experience or specific places.
	Local fear	Fear or concern that is tied to specific, familiar places such as one's neighborhood or frequently visited areas.
	Neighborhood safety	Generally refers to safety perceptions of immediate residential environments or a neighborhood, influenced by both subjective and objective elements. In this thesis, neighborhood safety may also refer to external perceptions, i.e. of non-residents.
	Visual Perceived Safety (VPS)	A specific form of situational safety that is based on visual impressions of the built environment. It reflects situational, often instinctive, safety assessments.
Spatial and social constructs	**Place**	A space shaped by both physical and geographic boundaries, functionality, social interaction, and symbolic associations. Rather than a non-descript point in space, it is imbued with meaning through human experience.
	Public place	A shared space open to general use, typically accessible without restriction, often designed to support everyday activities, enable social interaction, and facilitate movement through the urban environment.
	Place attachment	Positive emotional bonds to a location, often tied to routine, familiarity, and personal meaning.
	Place stigma/territorial stigma	Negative societal perceptions of a location (place, neighborhood, or region) can shape both external and internal safety perceptions.

3 Conceptual approaches

The common thread of the papers included in this thesis revolves around two key dimensions: (1) the data and methodologies used to measure perceived safety and (2) the specific dimensions of safety being assessed in an urban context. As per the theoretical review, safety perceptions are multifaceted and inherently complex, socially constructed, and resistant to simple categorization. Rather than seeking to resolve these tensions outright, the thesis embraces their multidimensional nature by exploring them through a series of contrasting dichotomies: global vs. local fear, situational and dispositional safety, subjective versus objective indicators of safety, as well as internal and external perspectives of neighborhood safety. The thesis incorporates both conventional and more emergent research methodologies to advance understandings of urban safety. Additionally, the role of space and place in shaping safety perceptions is central in all papers, whether as direct catalysts of fear or as contexts where fear is experienced.

The five papers contribute to this conceptual approach in complementary ways. Paper I uses a traditional approach of safety research, making use of official safety and victimization survey data and statistical analysis to particularly explore men's fear and the impact on their lifestyle and behavior. Both general worry of crime and neighborhood safety are compared and conceptualized as global and local fear, respectively, while behavioral impacts are investigated in the context of expressions of masculinity. Papers II and III utilize a more emergent combination of AI-methodologies and Big Data, combining deep learning models, Google Street View images, and a citizen survey to create *perceived safety score*. In Paper III specifically, this particular dimension is referred to as *visually perceived safety* – VPS, highlighting its situational nature and basis on visual impression of street environments. Paper II and III both use spatial and statistical analysis to investigate the relationship of VPS with other indicators of safety – safety survey results (Paper II), i.e. safety perceptions shaped through repeated experiences over time, and crime rates (Paper III), i.e. a measure of objective safety. Paper IV and V focuses on a specific neighborhood in Stockholm, Järva, which has suffered historically from both crime and poor safety, as well as continuous media stigmatization. Paper IV focuses on how different relationships to a location may moderate safety perceptions, using a PPGIS-based survey of residents, visitors, and non-visitors of Järva. Here, the concepts of place attachment and place stigma are used to better understand how a lack of knowledge or personal experience may lead to a poorer sense of safety. Paper V explores the potential of crowdsourced data collection to measure urban safety perceptions, investigating how the use of mobile apps could be

used to capture near real-time safety perceptions linked to geographic points and visual imagery. This paper particularly takes into consideration the perspectives of urban youth and their experiences living in a stigmatized neighborhood.

This approach bridges modern data sources and methodologies with theories and concepts within fear research, environmental and community criminology, environmental psychology, and urban planning. It offers multi-scalar analysis of safety perceptions comparison and critical evaluation of methodologies used to do so. By integrating these perspectives, the thesis contributes to a more holistic, both theoretically and empirically-informed understanding of perceived urban safety.

4 Methodology and data

4.1 Methodology

The studies included in this thesis employed a varied combination of methodologies and data sources. Table 2 summarizes the methods and data used in the appended papers. A majority of the papers use quantitative analysis, including spatial and statistical methods. Classical statistical methods such as chi-square tests and regression modelling underpin the foundation of most of the analyses. Qualitative analysis, in the form of text interpretation and workshop discussions, was also necessary to process some of the studies' results. Several papers utilize GIS to visualize patterns of safety perception over the given study area. The methods of generating or collecting data vary greatly between the papers, including online surveys, deep learning models, mobile apps, sometimes in combination.

Table 2 - Methods and data utilized in the papers

Paper	Methods (Data collection)	Methods (Analysis)	Data sources
Paper I: Men's fear in public places: a Scandinavian case study	• Survey (secondary source)	• Chi-square analysis • Regression analysis (Binomial)	• Stockholm Safety Survey 2020

Paper II:
Assessing Differences In Safety Perceptions Using GeoAI and Survey Across Neighborhoods In Stockholm, Sweden
	• Survey (Image-based, citizens panel)
	• Survey (secondary source)
	• Retrieval of official data
	  ○ Urban planning and land use
	  ○ Socioeconomic data
	• Deep learning algorithm
		• Spatial descriptive analysis
		• Regression analysis (OLS, SAR, SEM)
			• Google Street View database
			• Stockholm Safety Survey 2020
			• Sweco
			• OpenStreetMap

Paper III:
Crime And Visually Perceived Safety Of The Built Environment: A Deep Learning Approach
	• Retrieval of official data
	  ○ Police-recorded crime
	  ○ Urban planning and land use
	  ○ Socioeconomic data
	• Production of perceived safety score (same as Paper II)
		• Spatial autocorrelation (Getis Ord Gi*)
		• Regression Analysis (Spatial Lag)
			• Swedish Police Authority
			• Stockholm City
			• Sweco
			• OpenStreetMap

Paper IV: From Locals To Outsiders: A Comparative Analysis of Neighborhood Safety Perceptions	• Survey (PPGIS)	• Spatial descriptive analysis • Regression analysis (Binomial) • Text analysis	• Maptionnaire Survey Platform
Paper V: Urban Safety in the Eyes of the Youth: A Mobile App Study of Swedish Adolescents in a Stigmatized Neighborhood	• Survey (Mobile app)	• Spatial analysis • Statistical analysis • Text analysis • Workshop discussions	• StreetEye (mobile app)

Surveys were used as a key method of data generation in all papers except Paper I, where survey data was utilized as a secondary source. Otherwise, surveys were either used in combination with other data-generating methods (Paper II and III) or as a single data collection method (Paper IV and V).

The formats of the surveys vary greatly between the papers. For instance, the datasets in Paper II and Paper III were partly generated from a survey where the respondents were tasked with pair-wise ranking a sample of street view images in terms of their perceived safety. This became the basis of the training dataset of a deep learning model, utilizing the survey results to predict safety scores for other Stockholm street view images. The sampling of both survey images and respondents was based on the six regional categories of Swedish urban planning styles (see Paper III), in order to represent perceptions from various environments. Paper IV employed the help of the survey platform Maptionnaire, which integrates traditional survey questions with interactive map inputs, similar to PPGIS-approaches. This allowed for insights into the geography of fear and poor safety in the study area (Järva), including spatiotemporal variations. In order to allow for distinction between the target respondent groups (residents, visitors and non-visitors of Järva), three different questionnaires were devised for the respective groups. This survey used a convenience sample, distributing through municipal online channels, e-mail recruitment, and on-site reach out. Finally, Paper V involved developing a mobile app to survey individual safety perceptions of young people. The mobile application is called *Street Eye* and was developed using the online platform Flutterflow. Several versions were developed in order to adjust questions and user-friendliness. The survey relied on participants using the app to take photographs of environments in the Järva district and subsequently answering several questions related to their safety perception. The app collected survey responses, photos, as well as the timestamp and

geotags of the images. The sample size consisted of 9 individuals aged 16-19 years working for the Järva city district during the summer break. Compared to the other surveys, this method potentially captured what could be the most accurate measure of situational fear, as it immerses the respondents in the environments directly at the time of assessments.

The most technologically advanced method applied in the papers undeniably involves the deep learning model approach of Papers II and III. Deep learning and other AI-methods have exploded in terms of significance in several fields, including criminology and urban planning. In the associated studies, the deep learning approach helped to create a broad measure of urban safety perceptions with high spatial resolution due to the association with street view images (point-level resolution). The model used in the referenced papers is based on a ResNet model (residual neural network), which is particularly used for image recognition purposes. In order to train the model, the aforementioned pair-wise comparisons of street view images were converted into a safety score, based on the frequency an image was selected as the "safer" of a pair. This safety score could then be input into the deep learning model, which was trained to classify street view images in terms of the safety score. Several validation methods were used. For instance, the sample was divided into a training dataset and a testing dataset, with the latter used to evaluate the model's accuracy. Additionally, a subset of images was manually reviewed to assess whether the assigned safety scores were logically consistent and aligned with expected patterns. It should be noted that the author of this thesis did not develop the deep learning algorithm personally, but was part of the same research team as the individuals who did so. Furthermore, the aim of the overall thesis is not necessarily to provide any technically detailed assessment of the deep learning algorithm (although it is provided in Paper II), but rather the potential use it has as a future safety research methodology.

The quantitative analysis in the papers typically consists of descriptive methods, such as visualization, chi-square tests, and cluster analysis, followed by regression modelling for further examination. Due to the geographic nature of the included data in several papers, GIS-tools, such as QGIS or GeoDa, were used to map and visualize the results. Chi-square analysis involves a statistical test for assessing the relationship between categorical variables by comparing observed and expected frequencies in a contingency table. This can help determine if there are any significant differences between groups in terms of a variable of interest; e.g. men's expressed worry about crime in Paper I or residents and visitors perception of Järva in Paper IV. Cluster analysis is a spatial statistical method that is used to measure spatial autocorrelation – the tendency of a geographic variable to correlate with neighboring values. Through this method, one can identify whether a variable of interest tend to cluster in space, such as the VPS-score in

Paper II. Getis-ord Gi* was the particular clustering method used, which identifies clusters in terms of both hotspots (high density of high values) and coldspots (high density of low values).

Paper I-IV all produced several regression models, each examining different dimensions of perceived safety (or its impacts) as the dependent variable. The choice of methodology influenced the way the safety measures were examined. Paper I and IV both utilized *bivariate logistic* regression (a form of binomial regression), studying measures of fear and related phenomena as binary outcomes and how individual characteristics could explain the likelihood of each outcome. The papers investigate how respondent characteristics and/or neighborhood variables influenced the *odds* of respondents expressing fear, poor safety, changing their behavior, or choosing to reside in a neighborhood. In contrast, Paper II and III utilized a combination of *linear regression* models: including ordinary least squares (OLS) regression and spatial regression models such as the Spatial Error Model (SEM) and spatial autoregressive models (SAR, AKA Spatial Lag Model). SEM and SAR are extensions to classical linear regression by accounting for spatial dependency and autocorrelation in the dependent variable. In the related studies, OLS-regression was typically first performed, followed by Moran's I tests on the residuals to detect spatial autocorrelation. These linear regression models assess how changes in independent variables correspond to variations in the dependent variable, in contrast to logistic regression, which evaluates the odds of an outcome occurring. Logistic regression was performed in the software SPSS, while OLS and spatial regression were mainly performed in the GIS-software GeoDa.

Qualitative analysis played a more prominent role in Paper IV and Paper V and primarily involved the interpretation of open-text responses from the surveys, as well as a workshop discussion (Paper V). Survey text inputs were analyzed using a thematic and exploratory approach, often identifying underlying sources of poor safety and descriptions of respondents' fear and safety in their own words. In Paper V, a workshop was conducted to both present preliminary results and deepen the understanding of the participants' experiences during the data collection. Notes from the workshop discussion were documented and used as the qualitative base of analysis. While the majority of studies in the thesis are quantitatively driven, the qualitative methods helped characterize and contextualize some of the statistical findings. Several of the papers' conclusions also highlight gaps that point to the value of further qualitative analysis in future research.

4.2 Data

The spatial nature of safety and fear were key dimensions of interest and central to the thesis, leading many of the study datasets to include geographic variables. This also required careful selection of units of analysis for each respective study. For instance, while the Street-view images and associated VPS-scores are available at the XY-coordinate level, Papers II and III notably used the 419 administrative zones in Stockholm called base areas (*basområde)* as the basis of the analyses. This was due to the need to control for the effect of land use and socioeconomic variables in the regression models, which are only available at base area level or coarser spatial divisions. Other papers (Paper I, IV and V) did not center any geographical units as key variables and could instead use the individual survey respondents as the unit of analysis.

Crime data (as used in Paper III) was provided by the Stockholm Police Authority for the years 2019 and 2020. The crime categories of interest included violent crime, vandalism, and street theft, only including outdoor events due to the nature of the study. To enable comparison with other variables, the crime data were aggregated to base area level. Due to non-uniformity in population sizes between base areas, certain areas were excluded from the analysis in order not to misrepresent crime rates per 1000 inhabitants. Land use functions (e.g., commercial, residential, industrial land, and POIs such as restaurants, bars, transport hubs) were obtained via the municipality of Stockholm as well as OpenStreetMaps. Socioeconomic and demographic data (e.g., neighborhood income level, number of foreign-born, elderly) were obtained from Sweco, an information service company employed by Stockholm Municipality. The secondary survey data, i.e., the Stockholm Safety Survey (Papers I and II), was obtained via the municipality of Stockholm. This included responses to survey questions, as well as registered information on the respondents' gender, age, neighborhood of residence, civil status, and more.

5 Summary of the papers

5.1 Paper I – Men's fear in public places: a Scandinavian case study

Rather than dismissing men as fearless, Paper I attempts to investigate men's fear and its impact in public places in Stockholm. Using statistical methods; chi-square analysis and binary logistic regression, we investigate the nature of men's fear and the effect fear has on their lives using 20 781 answers from the 2020 Stockholm Safety Survey. We operationalize fear in two ways: worry of crime, a more global and broad fear, and neighborhood fear, a more locally anchored fear. Findings indicate that while men are generally less fearful than women, intersections between respondents' gender, income level, and ethnic background show a complementary picture. Foreign-born men and those living in low-income areas expressed similar concerns of neighborhood safety as women overall. The factors influencing men's general fear of crime and neighborhood-related fear were found to differ, with e.g. Swedish-born and foreign-born men displaying opposite patterns across the two measures. Men who live in neighborhoods with more physical disorder and low social cohesion are also more likely to avoid places and engagement with people where they live, as well as changing routine activities. The paper finishes with recommendations for future research.

In Paper I, Vania Ceccato first presented the main idea of researching men's fear, while the rest of the conceptualization and general study design were part of a collaborative process between the co-authors. The author of this thesis was primarily responsible for drafting the original manuscript, processing the data, conducting the formal analysis, relating the study's findings to previous research and relevant theoretical frameworks, as well as drawing the final conclusions.

5.2 Paper II - Assessing Differences In Safety Perceptions Using GeoAI And Survey Across Neighborhoods In Stockholm, Sweden

Paper II attempts to provide an alternative, highly spatially accurate measure of urban safety that can be applied to a large area of analysis. Traditional surveys often capture neighborhood residents' perceived safety, but may not fully reflect the perceptions of people who are unfamiliar with the area. In this study, focused on the city of Stockholm, Sweden, we develop a geospatial artificial intelligence (GeoAI) approach using street view images and a citizen panel to create a measure of citywide citizens' safety perceptions. We compare the measures from the survey based on neighborhood residents' responses with those from the GeoAI approach to better understand the relationship between these safety measures. We model the two forms of safety perceptions and their disparities (i.e., perception bias) as a function of the city's land

use and its socio-demographics. Results confirm that while the GeoAI-based measures better capture people's instant impressions of the built environment across the city, the survey-based measures reflect their overall daily experiences of specific areas. Regions that appear to be economically vibrant and have inner-city streetscapes are perceived as safe places from visual appearance but are not always perceived as such by residents. Older adults tend to overestimate their likelihood of being victimized by crime, which may enlarge perception bias. The study concludes by critically assessing the potential ethical issues (e.g., spatial bias, population bias) in the proposed methodology and making suggestions for future research.

In Paper II, the author of this thesis was the second author. The paper's conceptualization and study design were largely collaborative efforts. The citizens' panel survey was jointly designed, while an external survey company ultimately carried out the data collection. The deep learning model algorithm was developed by co-authors affiliated with the MIT Senseable City Lab. The first author, Yuhao Kang conducted the majority of the methodological design, analysis, and manuscript writing. The author of this thesis contributed to the study design, data processing, the creation and preparation of key variables and datasets for analysis, and supported the interpretation of results in relation to previous research and theoretical frameworks. The author also wrote several sections of the paper, including parts of the theoretical review, analysis and discussion.

5.3 Paper III - Crime And Visually Perceived Safety Of The Built Environment: A Deep Learning Approach

Paper III investigates the potential link between crime and visual perceived safety (VPS), using Stockholm, Sweden, as a case. Central to the study is the same perceived safety score as in Paper II (here conceptualized as VPS-score), a detailed measure of visually perceived safety and situational fear, created by combining a deep learning model with a dataset of local street view images and citizen impressions. This measure is examined with traditional crime records to compare the city's distribution of safety and crime. Geographical patterns and spatial clusters of high and low levels of crime and VPS are detected, while spatial regression is used to explore the relationship between the VPS-score and crime, controlling for sociodemographics and land use factors. The results show that crime rates of different types (violent, theft, and vandalism) are significant predictors of poor VPS, but mismatching geographies of perceived safety and crime are common. The article discusses the findings and finishes by highlighting the impact of these results for research and practice.

Paper III builds on the same study as Paper II; however, in this case, the author of this thesis was the first author. The conceptualization was, once again, a collaborative effort. The thesis author was responsible for drafting the original manuscript,

processing the data, conducting the analysis, and formulating the conclusions. This paper also utilized data generated from the deep learning model developed in Paper II.

5.4 Paper IV - From Locals To Outsiders: A Comparative Analysis of Neighborhood Safety Perceptions

Perceived neighborhood safety significantly affects the quality of life and social cohesion of communities. However, the perspectives of non-residents are often neglected, despite their potential influence on local views. Paper IV addresses this gap by examining how locals (residents and frequent visitors) and outsiders (non-visitors) perceive safety in the largely stigmatized Stockholm district Järva. We use a digital mapping tool to allow citizens to map out their safety perceptions over the district. Surveying 592 respondents and using a mixed-methods approach, including regression and text analysis the study investigates the environmental, social, and emotional factors shaping these perceptions. Findings highlight how stigma, place attachment and familiarity play an important role in moderating safety concerns, as even minor first-hand experience with Järva was linked to improved neighborhood perception. The study concludes by reflecting upon the importance of addressing territorial stigma and promoting local engagement to improve local and outsider safety perceptions.

In Paper IV, the conceptualization, data collection, and survey design were conducted collaboratively. The author of this thesis was primarily responsible for drafting the original manuscript, processing the data, conducting the formal analysis, relating the study's findings to previous research and relevant theoretical frameworks, as well as drawing the final conclusions.

5.5 Paper V – Urban Safety in the Eyes of the Youth: A Mobile App Study of Swedish Adolescents in a Stigmatized Neighborhood

The fifth paper of the thesis explores the potential of mobile applications as a tool for capturing youth perceptions of neighborhood safety. Unlike traditional surveys, which are prone to recall bias, smartphone apps enable real-time, geotagged data collection, allowing participants to share safety assessments, photographs, and contextual insights on the spot. The study focuses on a sample of young municipal summer workers in the stigmatized Järva district of Stockholm, Sweden, using Street Eye, a mobile application developed to document and analyze safety perceptions in urban spaces. Following the app data collection, a workshop was conducted with participants to further contextualize their experiences. While there were several challenges related to the participant recruitment and execution of the data collection, the findings highlight the versatility of smart phone apps as a data collection tool for safety. The study

additionally contribute to a broader understanding of how adolescents experience urban safety within the context of stigmatized areas.

In Paper V, the conceptualization and survey design were carried out collaboratively between the thesis author and Vania Ceccato. The author of this thesis was primarily responsible for drafting the original manuscript, supervising data collection and workshop, processing the data, conducting the formal analysis, and relating the study's findings to previous research and relevant theoretical frameworks, as well as formulating the final conclusions. The mobile app used for data collection was developed by Taha Ali, based on the guidance and specifications provided by the other co-authors.

6 Discussion

This chapter discusses how the five papers of this thesis collectively showcase the multidimensionality of safety, particularly related to urban public space, presenting methodologies and theoretical frameworks that can be used to start disentangling the complexities. The findings highlight how both leveraging technological advancements and reexamining traditional notions in a modern context are necessary to understand and combat poor safety in the 2020s. The approaches of the studies reveal the possibilities of larger-scale analyses of safety perceptions and other safety indicators while retaining spatial resolution, the ever-present intersectionality of safety, and further implications of its intertwined relationship with place stigma and attachment. Together, the approaches of the studies provide a complementary picture of how to understand and measure modern safety perceptions. The discussion below will attempt to explore what knowledge the findings have generated and what implications they have for research and practice, particularly in the fields of criminology and urban planning.

6.1 Conceptualizations of safety – calls for distinction

Both previous research and this thesis argue that safety and fear must be approached through various lenses to capture their full complexity. As noted in the conceptual framework, several of the papers explore these lenses in conceptual dichotomies (see Table 3 for a summary). For instance, perceived safety can be partly considered through a global measure - reflecting an individual's general worry about crime and other dangers - and a local indicator, focusing on their safety perceptions of their immediate neighborhood (Paper I). As these measures were shown to have differing relationships across socioeconomic and demographic groups, this dual lens underlines the importance of distinguishing between broader societal safety concerns and the personal, neighborhood-specific factors that shape an individual's daily experiences. While criminologists recognized this early on (see e.g., Farrall et al., 1997; Hinkle, 2015; Garofalo, 1979), this thesis highlights its renewed relevance today. Paper I reveals that two measures of fear can have even inverted relationships across groups of men, showing that using only one measure of safety may obscure the vulnerabilities of certain groups. For instance, the poor safety of marginalized men would perhaps not have been identified had only measures of crime concerns been applied.

Importantly, the findings stress the necessity for continued intersectional and gendered analyses of safety perceptions. While much fear of crime research has focused on women due to their historically higher reported levels of fear, Paper I argues that lower levels of fear reported by other groups—such as men—should not be misinterpreted as

the absence of fear. Men's safety concerns, though often less visible, are shaped by unique social expectations and experiences, including fear of confrontation, violence, and social judgment (mainly with and from other men). This does not suggest a shift in research focus from women to men but rather a broadening of analytical and theoretical frameworks to ensure that the safety needs of all groups are acknowledged and addressed. Ensuring safe and inclusive cities requires understanding why even smaller subsets of the population feel unsafe and recognizing the diverse ways in which fear manifests and impacts daily life. For instance, Paper I also finds that men in fear may modify their behaviors in significant ways, such as avoiding certain places, altering their social interactions, and changing routine activities. To be able to address this we must also understand that the nature of these fear-coping strategies may be distinct from women's due to gendered societal and cultural conditioning and hegemonies.

Paper II highlights a different potential dual lens of safety. The VPS-score was used to show that our perceptions of safety are also, in part, shaped by our immediate visual interpretations of the environment, parallel to the concept of situational fear. This form of fear arises from real-time assessments of surroundings in terms of, e.g., maintenance, decay, obscured vision, and mobility, highlighting the influence of environmental aesthetics and maintenance in shaping how safe individuals feel at any given moment. However, as the paper shows, situational fear differs from long-term safety perceptions - such as those captured by safety and victimization surveys - which are cultivated over time through lived experiences and individual characteristics. This dichotomy continues to highlight that safety perceptions are not static but are continuously shaped by both immediate environmental stimuli and deeper socio-cultural and individual dispositional factors. It should be noted that the VPS-score is based on one question ("Which of these environments do you feel are safer/more unsafe?"), which lacks any reference to crime or any specific danger for that matter. The survey-based safety index combines three questions related to safety, including worry of crime, neighborhood fear and specifically night time-related fear.

Continuing the exploration of contrasting safety dimensions, Paper III further illustrates that there is indeed some correlation between objective safety (such as crime rates) and subjective, visual, safety measures (the VPS-score). It should be noted that in this paper, what is actually being measured is not whether crime rates influence visual safety perceptions, but rather whether criminogenic environments are perceived as unsafe. Environmental criminology theories point to the fact that several types of urban environments, conditions, and features that influence crime also influence perceived safety (Cozens and Sun, 2018; Wilson and Kelling, 1982; Fisher and Nasar, 1992), yet not always, not necessarily in a linear fashion, and sometimes even in opposing directions. The study finds that, overall, there is a statistically significant correlation

between crimes of several different types (including violent crime, street theft and vandalism) and visually perceived safety. The Getis-Ord Gi* cluster analysis revealed that there are some critical exceptions to this, however. The implication of low crime areas still being visually perceived as unsafe, once again highlights how urban design could potentially undermine residents' sense of safety and that crime deterring strategies are not necessarily sufficient to ensure subjective safety. This stresses the necessity to incorporate perception-based analyses in addition to crime data analyses when establishing comprehensive safety diagnostics, ensuring that urban design prioritize both objective and subjective safety.

Finally, safety perceptions were also shown to not only be derived from lived experiences or situational cues, but also heavily moderated by place attachment, familiarity and stigma. Paper IV showcases how even minor increases in lived experience and familiarity with a stigmatized location improve safety perceptions significantly. This aligns with previous research indicating that familiarity reduces fear by decreasing the unknown elements that often trigger anxiety in unfamiliar spaces (Tuan, 1990; Lorenc et al., 2013; Chataway, 2020). Conversely, both Paper IV and (to an extent) Paper V show how neighborhood stigma is able to erode this, as general negative societal perceptions and stereotypes about a neighborhood, even if unfounded, were shown to influence safety perceptions. The qualitative analysis also revealed signs of some racialized nature in some sentiments, where some respondents blamed the perceived poor safety conditions on “diversity” and high shares of immigrant populations. Previous research has pointed out how certain marginalized ethnic groups, such as Latinos and African Americans in the USA, can be perceived by residents as associated with features of poor safety, such as urban decay and instability (see e.g., Skogan, 1992, p.69). This is especially concerning as continued stigmatization, and poor safety conditions may perpetuate these racialized narratives and, by extension, exclusion, and inequality.

Even those who live in and are familiar with a stigmatized area may internalize external narratives, potentially leading to heightened fear and reduced place attachment. This further illustrates how safety perceptions are heavily influenced by external social constructs and media portrayals of certain neighborhoods as unsafe or undesirable. The interplay between place attachment and stigma demonstrates the emotional complexity of safety perceptions and the difficulty of disentangling them from other emotional perceptions and responses to the environments, which may also include pride, shame or alienation. As such, the thesis underscores that achieving safer cities requires recognizing the emotional dimensions of urban living. Safety perceptions are not merely reflections of crime rates or environmental design but are also shaped by how people feel about where they live, who they share the space with, and how their neighborhood is perceived by society at large.

Table 3 – Dimensions of safety measured and compared in each paper

Paper	Operationalizations of safety and fear	Dimensions of safety and fear compared
Paper I	○ Frequency of worry of crime the past 12 months ○ Safety perceptions of neighborhood	○ Global fear/dispositional fear ○ Local fear/dispositional fear

Paper II	○ Survey-based safety
	  ○ Worry of crime
	  ○ Neighborhood safety
	  ○ Safe outdoors
	○ Perceived safety score
	  ○ Pairwise ranking of urban environments
		○ Dispositional safety
		○ Situational safety

Paper II	○ Perceived safety score ○ Pairwise ranking of urban environments ○ Crime rates per 1000 inhabitants	○ Subjective/situational safety ○ Objective safety
Paper IV	○ Locals' (residents and visitors) neighborhood safety perception ○ Outsiders' neighborhood safety perception	○ Dispositional safety ○ Internal neighborhood perceptions ○ External neighborhood perceptions
Paper V	○ Adolescents perceived safety of location	○ Situational safety ○ Dispositional safety ○ Internal neighborhood perceptions (in relation to stigma)

6.2 Methodological approaches to measure and conceptualize perceived safety

The multidimensionality of urban safety calls for methodological pluralism in safety research. This section discusses the various methodological approaches to measure and quantify safety and fear throughout the papers, while critically assessing their potential and weaknesses (see Table 4 for a summary).

The use of secondary data sources, such as the Stockholm Safety Survey in Paper I, remains highly relevant in contemporary safety research. Its primary advantage lies in its convenience—as data collection has already been conducted, it significantly reduces the time, effort, and resources required for new research. The pre-existing dataset also facilitates the research process by offering ready access to a broad sample and a partly established framework for analysis. However, reliance on secondary data imposes notable limitations, particularly regarding control over sampling methodology and

questionnaire design. Researchers are confined to the original survey structure, which dictates what dimensions of safety can be measured. Consequently, safety perceptions may often be reduced to simplistic measures such as binary responses (“Yes” or “No” to expressing fear) or ordinal scales (e.g., Very Safe, Safe, Neither, Unsafe, Very Unsafe). This, of course, restricts the depth of analysis, as these scales may overlook the nuanced and situational aspects of fear that more tailored data collection methods could capture.

Nevertheless, large-scale official surveys often provide flexibility, as they often encompass a wide range of questions related not only to safety but also to adjacent concepts like disorder, social cohesion, and collective efficacy. This breadth allows researchers to explore how perceptions of safety interact with broader social and environmental conditions. Additionally, official survey data can easily be both linked to a range of individual characteristics of citizens– allowing for intersectional analyses - as well as geographically linked to respondents' neighborhoods, offering spatial analyses of fear and safety across the city. Yet, significant challenges arise from the sample size and spatial resolution. In many neighborhoods, the number of respondents is limited—sometimes as few as one—which undermines the reliability of comparisons across different areas. Secondary data sources like the Stockholm Safety Survey are useful for assessing macro- to meso-level safety perceptions and dispositional fear, yet they often fall short in larger-scale analyses of the geography of fear at a finer scale, due to the limited ability to amass the necessary sample size. Understanding how individuals experience fear in specific locations may require more localized and dynamic data collection methods.

There is also a “black box” in the room we have not yet addressed. AI technologies are often characterized by their opacity, and lack of interpretability, which has particular implications in the context of deep learning models used to predict safety perceptions. When using the model we “gain” the ability to generate safety scores which no human has had a true input on. As a result, when the model assigns a particular street as “unsafe,” the specific visual features driving that prediction—whether that be poor lighting, visible disorder, or lack of natural surveillance—may be difficult to pinpoint. This is especially true as the main survey question, as mentioned, captures a very broad sense of safety – not necessarily driven by cues related to crime or disorder. Quantitative analysis, including correlation and regression analysis, can help identify significant factors, and theoretical frameworks can help validate observed patterns, yet the ambiguity and uncertainty still remain. Consequently, in order to realistically incorporate AI-techniques in safety research and practice, there is a need for explainable AI (XAI) methodology, which could potentially provide visual explanations or feature

importance rankings that illustrate which environmental elements most strongly correlate with perceived safety (Doshi-Velez and Kim, 2017; Arrieta et al., 2020)

Table 4 – Advantages and disadvantages with the methods of measuring safety perceptions

Paper	Methodology	Advantages	Challenges
Paper I	Official surveys (2nd-hand source)	○ No data collection necessary ○ Potential for flexibility in safety dimension ○ Potential for temporal variability	○ Restricts control over questionnaire design ○ Recall bias ○ Costly or unfeasible for large-scale analysis or fine spatial detail
Paper II & Paper III	GeoAI-approach ○ Deep learning ○ Street View data ○ Image-Survey	○ Ability to "upscale" sample size and scale of analysis ○ High spatial granularity ○ Uniform units of analysis	○ Interpretability of the model output ○ Limited to specific dimension of safety ○ Lacks temporal variability (with available data)
Paper IV	PPGIS-based survey Comparison of residents, visitors and non-visitors	○ High spatial granularity ○ Inclusion of non-resident perspectives ○ Potential in showing temporal variation	○ Recall bias ○ Difficulties in acquiring sufficient sample size and distribution
Paper V	Mobile app data collection	○ High spatio-temporal granularity ○ Potential to collect multiple forms of data (text, images, geolocation, temporal information) ○ Captures most comprehensive measure of safety ○ Potential scalability	○ Requires additional features to minimize task ambiguity (Alt. demonstration) ○ Potentially difficult recruitment process

The use of PPGIS-based surveys, as in Paper IV, is not novel in spatial safety research (Mohamed et al.; Kyttä et al., 2014; Berglund and Nordin, 2007; Preto et al., 2016), as they are commonly employed to investigate how individuals perceive and interact with places. Paper IV highlighted how map-based surveys provide spatial context to safety perceptions, transforming otherwise abstract or generalized concerns into location-specific. Unlike conventional surveys, PPGIS-based surveys allow respondents to pinpoint the exact locations where they feel safe or unsafe. This naturally improves the

accuracy of fear mapping, and while recall bias remains an issue, it may be reduced as participants are prompted to spatially anchor fear and crime events. In this case, the safety dimension being measured is largely dispositional in nature. Yet, the survey is able to capture some situational elements of the respondents' fears - both in terms of spatial conditions as well as temporal information (day- and night-time safety). It also serves as a complement to crime data, especially in study areas such as Järva, where willingness to report crimes to the police has already been noted to be low.

The main novelty in the approach of Paper IV lies in the comparison of neighborhood perceptions of residents, visitors, and non-visitors of Järva. Considering other potential neighborhood users than residents is essential to increase regional interactions and reduce stigmatization and social segregation. This methodology helped identify how varying degrees of familiarity, as well as pre-conceived notions of a neighborhood, affect overall neighborhood safety perceptions. Most neighborhood-level studies within criminology and urban studies have been largely resident-centric models of safety, with few considering perspectives of non-residents with differing degrees of familiarity (exceptions include Onat and Sahin, 2017; Ergun and Yirmibeşoğlu, 2016; Traunmueller et al., 2016), nor the effect of attachment or stigma on safety. More studies adopting similar approaches are necessary to get an inclusive and realistic understanding of people's relation to space and how this influences safety. However, the operationalization of safety in the survey could be criticized. The question "Is Järva a safe area" implies an assessment of the neighborhood, compared to e.g. "How safe do you feel in Järva", which would be a more experiential and individually-centered measure. One could argue that the former question could give rise to a more "objective" assessment, or rather more aligned with general societal perceptions of the neighborhood. This was hinted at as there were a lack of significant individual predictors explaining the variance in safety. On the other hand, this particular formulation was chosen to better compare perceptions of non-visitors (for whom the second formulation would not make sense for).

The reason for the lack of studies of this type could also be based on methodological limitations. There was difficulty in targeting the three survey groups – most notably the individuals who frequent Järva but do not live there themselves. The intermediate position of this group and the transient nature of their interactions with Järva impeded their identification, compared to residents and non-visitors. Ultimately this lead to a lower sample size than desired, which restricted ability to make robust statistical comparisons between groups. Additionally, using PPGIS with groups with varying degrees of familiarity of the study area could also have implications for the spatial resolution of responses. Overall, PPGIS relies on the participants' ability to mentally map their experiences. This reliance on geographical and digital literacy may have

inadvertently excluded certain demographics groups. For instance e.g., older adults not familiar with digital interfaces, and younger respondents not familiar with map-tools may have had difficulty completing the survey. As such, this methodology may need refinement in future studies, both in terms of alternative PPGIS-designs to accommodate varying familiarities as well as more targeted strategies for visitor recruitment (e.g. collaborations with local companies).

Finally, the mobile app survey was one of the methodologies with the greatest potential in terms of spatiotemporal granularity and ability to capture the dynamic nature of safety. Compared to the other studies measuring situational elements of safety, the approach of Paper V does not rely on proxies of environments (such as Street View-images or maps), but immerses the participants in real settings. The digital interface is likely to have been particularly suited for targeting younger people, who engage more actively with digital platforms than conventional surveys. It also provides a rich dataset in terms of data types with each entry – visual, text-based, geographical and temporal data, providing the material for a comprehensive and in-depth analysis of participants' safety perceptions. For instance, it showcased the geography of young people's fear, while simultaneously identifying various types of environments and distinct urban features (such as stairways) associated with poor safety. At the same time, it revealed personal narratives and emotional responses associated with the locations, highlighting its ability to capture some dispositional elements of fear as well. This integration of quantitative spatial data with qualitative contextual insights could be a significant contribution to advancing the understanding of the geography of adolescent fear.

Theoretically, this approach may be one of the more efficient methods to capture micro-level safety perceptions at a larger scale. As it is a (at the moment of writing) publicly available mobile application, there is great potential for applying it as a crowdsourced data collection tool. It could even be used to overcome some limitations of other methodologies in the survey, such as providing an alternative database of street view images for the deep learning model, including nighttime images. However, there are some obstacles that were found to impede this potential. It is difficult to create a standardized input of images when a range of different individuals are responsible for the photography, which is not facilitated by the young age of the current study participants. While instructions were given, including an initial guided demonstration, the criteria for which place to document were, to some degree, still left open to interpretation. Furthermore, providing live demonstrations would restrict greater-scale crowdsourced collections, as it would become impractical at larger sample sizes. Future developments of the app could include notifications prompting when to take a picture (see, e.g., Kronkvist and Engström, 2020; Solymosi et al., 2018). On the other hand,

allowing participants to independently identify and select areas to document provides valuable insights into the subjective significance of places.

6.3 Navigating the tensions of capturing fear and safety

To summarize, the thesis acknowledges that fear and safety are not only multidimensional concepts but also contested ones - analytically, methodologically, and politically. The tension between how safety is conceptualized and how it is measured runs as a persistent thread across the studies. In practice, the operationalization of safety into survey questions, image ratings, or app-based inputs inevitably flattens some of its complexity. What is captured are not raw emotions or perceptions, but proxies: expressions, impressions, and reflections of fear shaped by language, environment, social norms, and technological interfaces. Arguments can be made that this is better said to be modeling safety perceptions rather than actually measuring them.

This thesis does not attempt to resolve these tensions but rather to explore them from different entry points. Each study makes choices—sometimes constrained by data availability or methodological tradition—about what version of "fear" or "safety" is being captured. Most of the core variables related to safety in the various study surveys were based on single-item questions: "Have you worried about crime the past 12 months?", "Do you feel safe in your neighborhood?", "Which environment feels safer?", "How safe is Järva?/What is your idea of the safety in Järva", and "How safe does this place make you feel?". These have largely enabled broader, scalable data collection and analysis, but inevitably simplify the layered, embodied and temporal dimensions of perceived safety. As a result, what emerges is not a unified or definitive measure of fear, but a set of partial representations. It is by juxtaposing these different formulations across the studies that the thesis exposes the boundaries, and implications, of the chosen methodologies.

These studies demonstrate that capturing fear is never a neutral act—it also defines and frames what fear and safety come to mean. The tools and methods we use shape not only how safety is documented, but also how it is constructed and ultimately acted upon. The thesis thus argues for a more reflexive and critical approach to the study of perceived safety: one that recognizes methodology as a force that not only observes the world but also shapes the categories through which it is understood. This has implications not only for research, but for how municipalities, planners, and designers interpret and address fear in urban environments. By embracing methodological plurality and conceptual openness, the thesis contributes to a richer and more responsible understanding of fear in urban space, one that avoids oversimplification while remaining practically relevant.

6.4 Limitations

Several limitations exist with the research presented. Some have already been addressed in the discussion, and other study-specific limitations are addressed in each respective paper. There are on the other hand some broader limitations and challenges that permeated the whole thesis work, which will be addressed here.

Data is perhaps the most prominent factor limiting the studies. The quality, completeness, and accessibility of even official data can vary greatly, which directly influences the validity of the findings. For instance, the potential of police-registered crime is notoriously hampered by the underreporting of certain offenses, which can have serious implications for predicting and mapping representations of objective safety conditions (Brantingham, 2017; Skogan, 1977). Land use variables may also not account for temporary or informal land uses that influence safety perceptions. Depending on the level of analysis, socioeconomic data may be restricted or inaccessible due to privacy issues. Furthermore, the standards and practices regarding processing spatial data can differ across authorities, including whether the data is by neighborhood-, zip code-, or XY-coordinate level. The need for spatial aggregation of especially socioeconomic data at the neighborhood level, due to privacy concerns, has remained a strong limitation of spatial analyses (Andresen and Malleson, 2013; Monteiro et al., 2018). Most notably, this dictated the unit of analysis of Paper II and II, despite that both the VPS-score and crime data were available at higher spatial detail. As similar studies to Paper III have shown that the relationship between crime and VPS can differ at varying geographical levels (Zhou et al., 2023), this limitation has potential implications for the validity of the findings. This issue is commonly referred to as the modifiable areal unit problem (MAUP) and has been a persistent limitation of spatial analysis (Fotheringham and Wong, 1991). Future studies could potentially attempt spatial disaggregation (see e.g., Monteiro et al., 2018) in order to analyze safety and crime at a finer level while retaining socioeconomic variables as controls. Methodologically, the conventional regression models used in this thesis may not fully capture variations nested within the often aggregated data. A multilevel modeling approach (such as those by Brunton-Smith and Sturgis, 2011; Zhou et al., 2023; Wyant, 2008) could better identify within- and between-group variance in safety perceptions and related predictors (e.g., by base- or DeSO-areas) (Camacho Doyle et al., 2022). However, such models require sufficient cases within each grouping to ensure robust and reliable estimates.

While one of the arguments of the thesis is that safety perceptions are not static but dynamic – shifting over space and time, the cross-sectional nature of the studies limits the ability to capture this fully. This limitation is particularly relevant given that the findings, especially from Papers IV and V, point to stark differences in how safety is

perceived during the day versus at night, not to mention potential seasonal variations. These challenges largely coincide with the limitations of data availability and collection. For example, the lack of night-time street view imagery constrained the analysis of visually perceived safety in daytime settings, thereby excluding a critical dimension of how safety is experienced in practice. Data from several iterations of the Stockholm Safety Survey are available, but the questionnaire and sample size have differed greatly throughout the years, which hinders measurement of reliable trends. Longitudinal studies could significantly enhance our understanding of how safety perceptions evolve over time, especially alongside other phenomena such as stigma and attachment, but also physical changes in the urban environment and demographic shifts. Future research could consists of follow-up studies building upon the findings of this thesis, or independent longitudinal studies of the same or similar cases.

For the studies focusing on the Stockholm district of Järva there was a range of challenges that restricted both data collection and analysis. Both the PPGIS-survey and the mobile app survey acquired less than desired sample sizes. While the difficulties of the distribution of the survey and recruitment of respondents have already been discussed, there is a general limiting factor linked to the study area. Järva is one of the most studied areas in Stockholm when it comes to safety and security, catching the interest and focus of researchers, public authorities, as well as private companies. As the study included direct interactions with the population in Järva in various fashions, it was evident that there was a certain fatigue present – not only of surveys and research projects but specifically those related to crime and poor safety. Furthermore, as has been partly addressed in Paper V, one must consider the power dynamics between the researcher, as an external state-affiliated actor, and the study participant, who resides in a historically socioeconomically disadvantaged and stigmatized area. Future studies in similar study areas need to consider this relationship, which could potentially be addressed through greater community outreach and collaborations together with official authorities and local organizations.

7 Recommendations and conclusion

7.1 Recommendations for future studies

The findings presented in this thesis can serve as a foundation for future research, highlighting several areas for further exploration and methodological advancements.

Future research on men's fear in public places, especially in a Stockholm-context, should incorporate qualitative methodologies, such as in-depth interviews, ethnographic studies, and participatory research, to better understand how masculinity and gender norms influence men's expressions, perceptions, and coping mechanisms related to fear. Special focus should be given to marginalized men, whose perceptions may consist of layered insecurities related to housing or economic instability, racial profiling, or hate crimes. Further exploration of the role of territorial stigmatization on marginalized men's safety could also be beneficial.

Studies using GeoAI-approaches to create measures of urban safety could explore alternative databases of street view images and other environmental proxies - see e.g., crowdsourced options such as Mapillary and Panoramax (Mapillary, 2025; OpenStreetMaps, 2025). Possibilities to utilize virtual reality environments could create more immersive surveys, better reflecting the situational and experiential nature of fear. Additionally, exploring the effect of different units of analysis, such as street segments, could give more detailed and accurate insights into the relationship between VPS and crime. The use of mobile app-based surveys, as demonstrated in Paper V, has shown great potential for capturing high-resolution, real-time safety perceptions. Future research could further optimize this approach by exploring, e.g., automated prompts and gamified engagement strategies to increase participation and standardize data collection. Additionally, studies should investigate how real-time mobile safety data can be integrated with traditional crime data and environmental assessments to provide a more dynamic and interactive understanding of urban safety

The cross-sectional nature of the studies suggests that the findings could be expanded upon through longitudinal analysis, particularly by focusing on neighborhoods undergoing urban renewal or demographic shifts, or tracking the development of territorial stigma over time. Data permitting, multi-level and/or fixed effects models could both strengthen causal inference and better account for unobserved heterogeneity across areas and time, allowing researchers to distinguish between persistent structural characteristics and short-term changes affecting safety perceptions. Comparative multi-case studies could also provide insights into how stigmatization varies across different urban contexts, helping to identify the potential need for tailor-made strategies for

reducing social and spatial inequalities. Studies building on this thesis could also benefit from further employment of theoretical frameworks from the fields of environmental and community psychology.

There is also a need to investigate the extent to which these findings apply beyond metropolitan contexts like Stockholm. Future studies should explore how environmental, social, and economic factors influencing safety perceptions vary along the rural-urban continuum, as well as how rural-specific conditions - such as limited emergency response services, low natural surveillance, social isolation, and distinct social norms (Abraham and Ceccato, 2022), shape fear and perceived safety. Additionally, researchers should assess the feasibility of the methodologies presented in this thesis in smaller cities, where sample size limitations pose an even greater challenge. Testing whether PPGIS-based safety mapping, mobile data collection, and AI-driven safety assessments remain effective in less densely populated areas is essential for broadening the applicability of urban safety research.

Finally, greater effort should be devoted to developing unified and operational frameworks for studying and addressing perceived safety and fear. While several systematic models – including Problem-Oriented Policing (Goldstein, 1979), Situational Crime Prevention (Clarke, 1980), CPTED (Jeffrey, 1971) and the 5Is framework (Ekblom, 2010) - have been observed to enhance perceptions of safety, they were primarily designed for the prevention of crime. As a result, there remains a lack of dedicated models for consistently diagnosing and responding to the various psychological, social, and spatial dimensions of fear. Bridging this gap would improve research comparability and provide a stronger foundation for planning and policy that address safety beyond crime rates.

7.2 Recommendations for policy and practice

Based on the findings and discussions presented in the articles and thesis, several general recommendations can be outlined for planning practitioners and policymakers to enhance urban safety. These recommendations largely align with the United Nations Sustainable Development Goals (SDGs; United Nations, 2015), particularly SDG 11 (Sustainable Cities and Communities), which emphasizes the need for inclusive, safe, resilient, and sustainable urban environments, as well as SDG 16 (Peace, Justice, and Strong Institutions), which advocates for safe and inclusive societies.

- Urban planners need to adopt a multidimensional understanding of safety in order to choose the right measure, as well as be precise in their language when identifying issues. Is the sought-after dimension related to crime concern or their perception of the built environment? Measures need to be tailored to different

city users with differing perceptions and vulnerabilities. This involves intersectional perspectives of gender, ethnicity, age and socioeconomic status, but also to consider perceptions of both residents and non-residents (e.g., visitors and commuters) to avoid overly localized biases. Second, safety assessments should integrate both long-term and short-term trends, local and city-wide perspectives, and situational and dispositional factors. Additionally, quantified safety measures such as AI-generated safety scores should complement, not replace, traditional measures, ensuring that the human experience remains central to safety assessments. This approach would help governing bodies to fulfill SDG 11.7, which aims to promote safe, inclusive, and accessible public spaces for all, particularly vulnerable populations

- Increasing the availability, accessibility, and granularity of official statistics and data is essential for developing more complete safety diagnostics. Beyond socioeconomic and land use data, alternative datasets, such as municipal open-source databases of street-level imagery, could offer greater flexibility in data access and help address gaps or inconsistencies in existing datasets. Additionally, more transparent data-sharing frameworks between law enforcement agencies, municipalities, and researchers could foster evidence-based policy interventions while maintaining ethical and privacy considerations. As this helps ensuring public access to information, this also contributes to sustainable societal development (SDG 16.10)

- To reduce neighborhood stigma and improve both external and internal perceptions of safety, policies should strengthen intercommunity ties through inclusive events, awareness campaigns, and cross-neighborhood initiatives. These efforts can foster trust between different communities, challenge negative stereotypes, and enhance social cohesion, which has been shown to improve perceived safety. Achieving this requires collaboration among urban planners, law enforcement, businesses, community organizations, and researchers. Co-creation strategies that involve residents in shaping safety initiatives could further enhance relevance and local acceptance. PPGIS-methodologies could be used together with multiple communities in order to bridge spatial and social gaps. This approach directly supports SDG 11.3 which calls for participatory, integrated, and sustainable human settlement planning, as well as SDG 16.7, which promotes inclusive, participatory, and representative decision-making at all levels.

7.3 Contributions and concluding remarks

This thesis examines the complexities of perceived safety in urban environments, offering new insights into its definition(s), measurement, and quantification. By integrating traditional methods such as surveys, regression models, and spatial statistics, together with emerging approaches like deep learning and mobile-based data collection, it advances a more nuanced understanding of urban safety perceptions. Grounded in environmental criminology, urban planning, and environmental psychology, the research adopts a multi-level, intersectional approach to studying fear.

To summarize, the thesis has provided both theoretical and methodological contributions to several research fields across the studies:

Paper I expands on the theoretical discussions on intersectional criminology and the gendered nature of fear. It reinforces previous research while further highlighting how the choices in measures can obscure or reveal vulnerabilities of marginalized groups. Aside from women not necessarily feeling more afraid than marginalized men, the finding that concerns of crime and neighborhood safety have opposite directions for foreign-born status is notable. Researchers and policymakers may need to carefully consider how we measure, interpret, and address safety concerns within the increasingly diverse urban populations of the 2020s.

Paper II further contributes to our theoretical understanding of situational and dispositional fear, operationalized as the perceived safety score and survey-based safety. Rarely (if ever) have there been comparisons of citywide, instant assessments of environments compared with local, stable perceptions. The discrepancy between these views highlights the relational nature of safety (similar to Paper IV), which must be understood to capture perceptions of people not only where they reside. Methodologically, the paper expands on the fields of GeoAI in urban safety research by applying a locally trained dataset, and showing how it complements survey data to spatially map safety perceptions at a granular level. From this approach, tools can be derived to be of use by urban planners to identify where visual and lived experience in the built environment are not in accordance.

Paper III bridges environmental criminology with research of environmental perception, specifically comparing crime rates and visually perceived safety. It highlights once again the feasibility of deep learning models to create safety measures, while confirming that there is a significant link between some aspects of safety and crime, but also problematizes assumptions of a linear relationship. Similar to Paper II, this approach helps planners and other practitioners to identify areas with low crime rates, but where visual cues suggest unsafety (and vice versa). Safety planning must not only be defined

by crime prevention strategies but be paired with understandings of how spaces are experienced, if only visually.

Paper IV expands on the positional and relational dimension of safety by considering non-residents' perspectives of neighborhoods. It is perhaps the paper with the most intersecting research fields, bridging criminology, urban studies and community psychology, by filling in a gap of how familiarity, attachment, and stigma influence perceived safety. Territorial stigma is shown to be an important influence on external safety perceptions, yet even minor efforts to increase neighborhood interactions may yield great improvements.

Paper V showcases a tool to measure the experiential nature of safety, able to capture spatio-temporal dynamics combined with visual data inputs. Its mixed-method approach also helps to further expand upon how internal neighborhood perceptions may be affected by external territorial stigma, as well as coping responses to that stigma, particularly among youth. The methodology of the paper opens up for participatory, crowdsourced safety mapping, which may help capture perceptions of underrepresented groups such as youth.

Together, these studies demonstrate that perceived safety is not a singular or static phenomenon, but a complex, relational, and socially embedded experience. By investigating fear across different spatial scales, user perspectives, and methodological approaches, the thesis highlights the limitations of traditional crime-focused safety metrics and the importance of incorporating perceptual, emotional, and contextual dimensions. The contributions extend beyond academic insights, offering practical implications for urban planning, design, and policy, particularly in recognizing the significance of territorial stigma, the role of familiarity and place attachment, and the need to account for underrepresented voices in safety diagnostics.

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