ORIGINAL PAPER

What makes a railway station safe and for whom? The impact of transit environments on passengers' victimisation and safety perceptions

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Abstract

This study assesses patterns of victimisation and safety perceptions among passengers using railway stations across neighbouring municipalities in Sweden. Exploratory data analysis and logistic regression models underlie the methodology of the study, which shows that the geography of passengers' victimisation differs from the geographical patterns found for the perception of safety. Findings show that passengers' safety perceptions are more affected by the physical and social characteristics of transit environments than passengers' victimisation. Yet, for those who have reduced mobility, the station affects the likelihood of their being victimised. Lack of staff and poor maintenance of the station are two significant attributes associated with the lower levels of safety perceived by passengers as well as levels of crime and panhandling at both the station and on the way to it. Compared with all passengers, women, but in particular those who identify as LGBTQI+ /Non-binary/Other, run a higher likelihood of feeling less safe. The theoretical and practical implications of these results are discussed.

Keywords Transit safety, Crime, Fear of crime, Environmental design, CPTED, Scandinavia

1 Introduction

Safety is an essential dimension of our daily mobility [59]. When we travel by public transport, we spend a significant proportion of our travel time waiting for transport at nodes, such as train stations, or on our way to or from them [34]. If transit environments are criminogenic or perceived as such, our mobility can become limited [60], or we may consider other alternatives for transportation, including less sustainable ones. Not only are illumination and the design of transit environments key factors

according to two recent reviews of the literature [7], but the social environment also affects safety conditions. Guardians, traders and in particular place managers, such as station staff, have control over the place and people who use these places and in doing so, they also contribute to public order and safety [19, 23].

In this study, we contribute to the existing literature on transit safety by examining the influence of characteristics of the physical and social environment in different railway settings on the likelihood of passengers' victimisation and poor safety perceptions. We also investigate what makes a station (un)safe and for what types of passengers, by carrying out fieldwork inspection and analysing primary data (photographs, checklists) and secondary data (the station's features) through the use of descriptive statistics and logistic regression models. The theoretical and practical implications of the analysis are discussed to

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make recommendations to improve safety conditions in railway stations.

Although the literature on transit environments is rich, showing examples of how these environmental attributes affect rail-bound safety (e.g., [31, 33, 45, 46]), rarely do they combine evidence on crime and safety perceptions across different municipal contexts. This research is unique because it draws from survey data from 47 railway stations across 28 selected contiguous municipalities. The study also contributes to the international literature on transit safety by adding evidence to the Nordic context, in particular from the densest regions of Sweden serving approximately 64,000 passengers a day, which is, according to the Swedish Transport Administration, a rough estimate of the annual average day per station [57].

In this study, *victimisation* includes theft, robbery, violence, threats or hate crimes, sexual harassment, stalking and 'aggressive panhandling', which is an activity frequently found in transit environments, in particular in and around stations and indicated by previous research [7, 54, 56] as a major factor affecting perceived safety by passengers. Aggressive panhandling is a form of solicitation made in person for immediate donation of money or other gratuity, often involving manipulative, coercive, or intimidatory behaviour for monetary gain [4].

Safety perceptions are used in this study as an umbrella term for fear of crime and other anxieties that are expressed by railway passengers at stations and during their trips, and this can vary over time. Low safety perceptions are affected by a wide array of environmental factors and also passengers' characteristics, as discussed in the next section. Informed by principles of environmental criminology, we first provide a literature overview of crime and victimisation in transit environments, with an emphasis on environmental attributes. Then we introduce the research questions and the research design (data and methods), followed by findings from the analysis. We conclude with recommendations on how to amend the environmental characteristics of transit settings to minimise crime and promote safety for train passengers.

1.1 Passengers' safety: Crime and safety perceptions in transit environments

The way passengers perceive transit environments depends on their characteristics, such as age, gender, previous victimisation, and the characteristics of the physical and social environments they are exposed to on the way to the station. Table 1 summarises the most relevant factors affecting passengers' victimisation and safety perceptions in transit environments based on the international literature of the last five decades [7, 56] with a particular focus on rail-bound systems, which are split here into three groups: individual (1), station (2) and surrounding areas (3). Although the impact of these factors has been consistent across many studies, there are causal relationships that are inconclusive and/or dependent on the methodology implemented in the study or many other factors such as location and type of transit system, type of passengers or the intersectionality of individual characteristics of passengers. Good Lighting conditions reduce victimisation, but do not always influence women's safety perceptions positively. Appropriate lighting does not mean blinding lighting conditions, which can create a 'fishbowl effect', namely where the interior of the train is overly lit (rail carriage), while the external environment on the platform, for example, is dark. This effect creates a situation where a passenger (who is inside an overly lit wagon) can be seen by individuals on the outside of the train who are looking in, but, due to the glare of the lights on the window, the person cannot see outside of the train. Paths from home to the station might have these light conditions in which the lighting is unevenly distributed (too focused at the centre and insufficient at the edges) producing the 'fishbowl effect'. Below, we briefly discuss the main trends.

1.2 Passengers' characteristics

Previous research has shown that women, elderly people and people who declare having a disability, as well as those who have previously been victims of crime, report the transport system as less safe (Table 1). Yet, one cannot describe women's experience of public transit as being the same for all women. This calls for a holistic approach to safety that encompasses an understanding of the intersectionality [16] of victimisation and fear, namely the idea that fear and victimisation are not only influenced by gender, but are rather a result of the intersection of an individual's characteristics. Research shows that transgender and gender-nonconforming individuals often experience harassment, which undermines their access to safe public transportation [41]. The interactions of LGBTQI+ status with ethnicity and socio-economic status are also reported in the current international literature. Equally important is the impact of disability on transit safety. Watermeyer and Swartz [62] suggest the need to specifically consider disability as a starting point of analysis as opposed to being a secondary, auxiliary category after gender and race.

1.3 Characteristics of stations

The environmental design of a station, such as entrances and exits, affects surveillance, and can affect opportunities for crime. The literature shows plenty of evidence of the impact of restaurants, CCTV, illumination, staff, surveillance, and guards. Table 1 illustrates the most common aspects pointed out in the

Table 1 Factors affecting passengers' victimisation and safety perceptions in transit environments[a].

	Crime/Victimisation	Studies	Safety perceptions	Studies
Individual characteristics	Women (+), gender minorities (+), young (-/+), ethnic minorities (+), disability (+), LGBTQI+ status (+)	Madan and Nalla [42], Whitzman [64], Gekoski et al. [25], Lubitow et al. [41], Iudici et al. [27]	Women (-), young (±), ethnic minorities (-/+), disability (-), income (+), education (-), previous victimisation (-), frequency of use (±), families' and peers' high safety perceptions (+), LGBTQI+ status (-)	Lois Garcia et al. [35], Aitbihiouali et al. [1], Yavuz and Welch [66], Sundling et al. [55], Zegras et al. [69], Stark and Meschik [53], Ceccato et al. (2021); Wayland et al. [63], Chowdhury and Wee [13]
Station characteristics	In/formal surveillance (-), Emptiness (+), crowdedness (-/+), CCTV(-), territoriality (-), control of access (-), underpasses (+), open environments (±), maintenance (-), large station (+), lighting (±) emergency alarms (-), Information Communication Technology, ICT (-), available big data analysis (-), new resistant materials (-), body-worn cameras, BWC (-)	Ouimet and Tremblay [47], Block and Davis [3], Piza et al. [48], Smith [52],Ceccato [6], Wilson and Kelling [11, 65]; Debrincat et al. [18], La Vigne [32], Ariel et al. [2]	Open environments (±), illumination (+), staff (+), cafés/kiosks (+), CCTV (+), security guards (+), police (±), isolated places (-), basic amenities (benches, shelters) (+), maintenance (+), mobile phone coverage (+), trust in staff/other people (+)	Cozens et al. [15], Lorenc et al. [36], Coppola and Silvestri [14],Aitbihiouali et al. [1],Yavuz and Welch [66], Chowdhury [12], Lubitow et al. [41], Kennedy [29], Fan et al. [22], Vanier and Jubainville [60], Kim [30]
Station location and area characteristics	Central location (+) (for women), end stations (+) (for men), (liquor) stores, bars, pawnshops & restaurants (+), vacant car parks (+), close to bus stop (+), local centres in disadvantaged neighbourhoods with low collective efficacy (-), high-crime neighbourhoods (+)	Moreira and Ceccato [43], Yu [68], Hart and Miethe [26], Loukaitou-Sideris et al. [39]	Isolated streets, criminogenic area (-), fragmented suburbs (-), "human-scale" buildings with streets in X-intersections (+)	Kennedy [29], Coppola and Silvestri [14],

[a] In the column "crime/victimisation," a positive sign (+) indicates that a particular factor increases victimisation (e.g., being a woman is associated with a higher risk of victimisation in previous studies), while a negative (-) sign means a reduced risk of being victimised, while a positive sign (+) in the column "safety perceptions" means that a particular factor increases safety, while a negative sign (-) indicates a reduction (e.g., women tend to declare lower safety perceptions than men)

international literature, such as a station's emptiness, open environments, cafés/kiosks, underpasses, station size, lighting, CCTV, body-worn cameras, maintenance, etc. In the train stations, for example, we found that what happens in the stations depends not only on their physical environments but also on human activities that take place at these transport nodes and in the surrounding areas, including the presence/absence of staff. We turn now to discuss these effects. Moreover, a recent study on young passengers in public transportation in Stockholm found that although only 7% were victims of crime, 48% of them were subjected to sexual harassment [9], which means that safety perceptions can reflect a variety of social interactions in transit, including aggressive panhandling. This also applies on the way to and from stations or bus stops [10, 37, 52].

1.4 Location of stations and area characteristics

Transit stations exist in a context; their external characteristics, such as the socio-economic conditions of the resident population where the station is located, also affect the incidence of crime within the station as well as passengers' safety perceptions at the station and on the way to the station. The international literature is unclear as to whether this evidence also applies to railway stations in, for example, smaller municipalities. There is also a knowledge gap about which crimes are committed in station environments and the surrounding environments adjacent to the railway.

For this case study, we followed the recent strand of Western research on transit safety and set out to investigate the following research questions.

> RQ1 – Which passengers are more likely to become crime victims? Does this victimisation vary according to different environments at the stations and during the trip (at the station and on the way to/from the station)?
>
> RQ2 – What makes a railway station safe? Are passengers' victimisation and/or safety perceptions affected by the internal stations' environment and during the trip?
>
> RQ3 – Does previous victimisation affect people's perceived safety? Are different passengers affected by the conditions of the stations?
>
> RQ4 – What are the common factors that affect passengers' victimisation and safety perceptions in railway transit environments? What are the changes/recommendations needed for improving passengers' safety in railway environments?

1.5 The study area and the research design

The study area is composed of 47 stations distributed over three railway lines stretching through central and southern Sweden, serving 28 municipalities, which together have a total population of 1.78 million inhabitants [50]. Sweden has 10.4 million inhabitants and one of the largest land areas in Europe (87% of the population live in urban areas, which cover 1.5% of the entire land area). The population density is substantially higher in the south than in the north, where the study area is located. The second largest city (with about 580,000 inhabitants) belongs to the study area, but the capital city, Stockholm, does not [50]). Figure 1 shows the railway lines that belong to the study area and the number of passengers per day for each station. A categorisation of station size with respect to passenger flow shows that seven stations have more than 2,000 daily passengers; then there are 18 stations with fewer than 500 daily passengers, while 22 stations serve 500–2,000 daily passengers, covering a variety of rural contexts (Fig. 1).

To detect differences in the stations' environments, we conducted a systematic and detailed inspection of all stations (including photographic documentation), including a check on their surrounding areas in winter 2021 in cooperation with the National Association of Transit Riders (Resenärerna), as well as in a selected group of stations during summer 2022. The photographs served as visual documentation of aspects of the stations (design, layout, the flow of people, time of the day/night, etc.), providing a detailed and accurate representation for analysis, capturing specific aspects of the environment, conditions, or subjects relevant to the research.

Following approval by the Swedish Ethical Review Authority, data was collected between May and September 2022. We combined answers from two quasi-identical surveys, one in print and one online (32 questions in print and new questions were added to the online version, a total of 47 questions). These questions serve as the basis for the survey "*To promote safe stations*", specially designed to capture the importance of the physical and social environment of the stations in the Swedish context. To promote the survey, posters and cards were set up during fieldwork inspections in the summer of 2022. The survey was also distributed in Facebook groups by the municipalities and by other groups and organisations. Researchers participated in radio programmes promoting the research project and encouraging people to answer the survey. Note that although the total sample was composed of 4,893 passengers combined ($N_{printsurvey}=2,180$ and $N_{onlinesurvey}=2,713$), the sample is not representative of passengers at all stations. A minimum of 25 respondents was established, but two stations did not reach this total because the number of passengers was too small
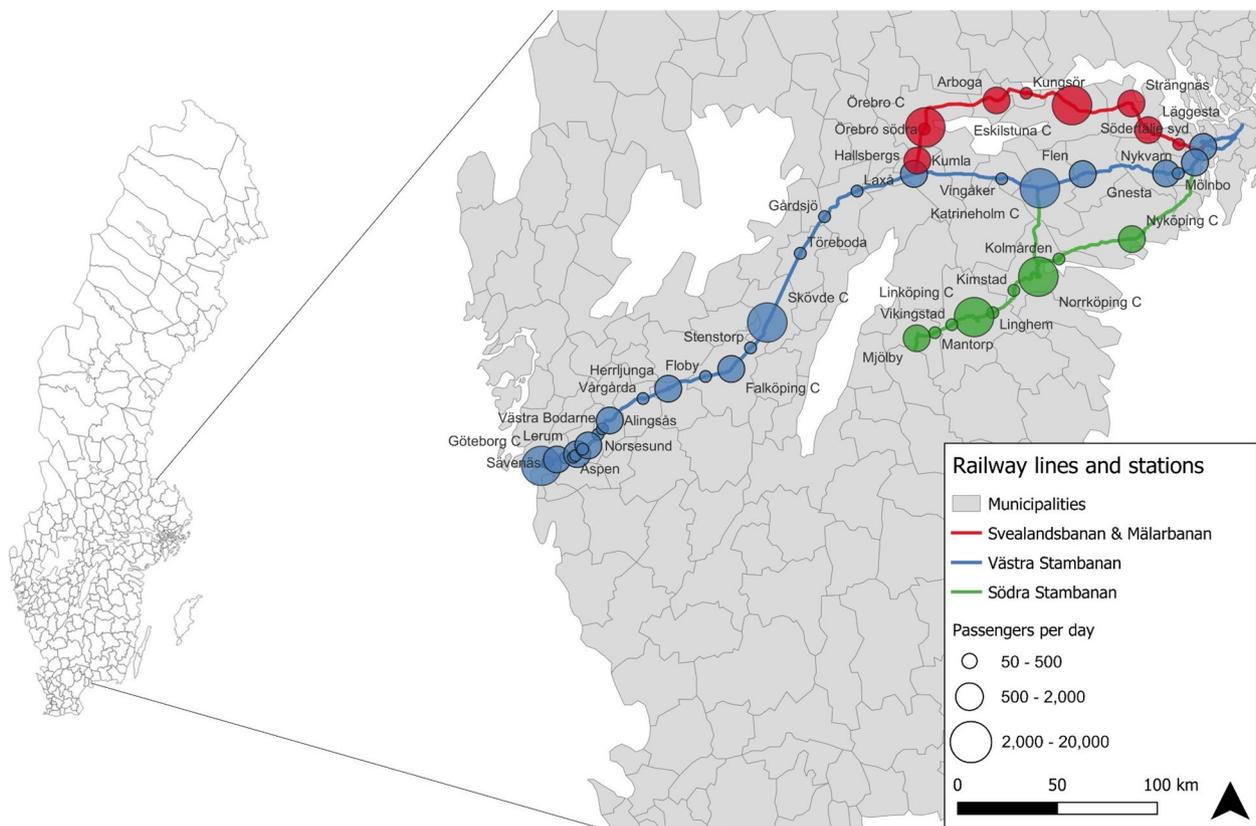
Fig. 1 The study area. Source: Authors

(rural station). Due to the way the survey was delivered (both face-to-face and online), it is not possible to calculate an exact response rate, but the sample of the printed survey was calculated so the results can be statistically split by track, station size, gender, age, and time of day. Additionally, we had to exclude $N=784$ answers because the passengers did not travel from/to stations within the study area, invalidating a few core questions. We also interviewed ten representatives of train operators and public officers (experts and key safety railway professionals) between October and November 2021. This information was also used in the section on recommendations.

In our sample, 61% of respondents identified as female, 34% as male, 3% as LGBTQI+ (lesbian, gay, bisexual, transgender, queer, or intersex) and 2% as non-binary or other, which means that women are overrepresented in our sample. The sample consisted of mostly young people, where the great majority of respondents (22%) were between 18 and 29 years old and an additional 8% under the age of 18, whereas those over 60 years old accounted for 14% of the sample. There was also a disproportion of Swedish-born passengers in our sample, as they made up 88% of the respondents, with only 12% being foreign-born passengers.

The majority (33%) of the passengers in the survey used the train less frequently than once a month, but many (27%) were also frequent passengers using it at least 4 days per week. Most responses (52%) came from passengers who travelled on the blue line (the longest). Nearly half of the respondents departed from a middle-sized station (500–2,000 daily passengers), 35% from a large station and 20% from small stations.

2 Methods
The survey consisted of four parts: introductory questions about frequency of use, where the trip departs from, most frequent times of the trip, a main section on victimisation and safety perceptions by different types of trips and station environments, and by type of victimisation. The survey also included questions about the impact of crime and fear and recommendations for improving safety conditions during the trip as well as a final section on background information about the passengers, such as gender, age, income, ethnic background, sexual orientation, and disabilities. The questions used in this analysis were:

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- Victimisation – *"In the past 5 years, have you been victimised by crime on the train, at the station or on the way to/from the station? (A list of crime types included theft, robbery, violence, threats or hate crimes, sexual harassment, stalking, aggressive panhandling.)*
- Safety perceptions – *"When travelling by train, do you often feel afraid of being exposed to the following? (A list of crime types.)*
- Recommendations – *"Can you indicate which of the following could make your journey by train safer? (A selection of 18 constituted the alternatives, see Fig. 4.)*

The data from the survey was transferred from the web-based platform, *Crowdsignal*, via Excel to the statistical software package SPSS in which the analyses were carried out (IBM SPSS Statistics, 28.0.1.1). We used Geographical Information Systems (GIS) to map relevant land use and included variables that indicate the demographic and socio-economic contexts of the stations (such as income, and age). Three separate databases were combined into a large database. A data quality analysis indicated that a few variables had a relatively lower response rate than the average response (80% of all questions), which affected the analysis by reducing the number of observations. The variable age of respondents was an example. We also excluded responses from passengers who started their trip outside the study area (16%), because we were unable to link the attributes of the stations with their responses.

We categorised the stations in several ways: by size (a categorisation of station size concerning passenger flow shows that seven stations have more than 2,000 daily passengers; then there are 18 stations with fewer than 500 daily passengers while 22 stations serve 500–2,000 daily passengers, covering a variety of rural contexts); by the type of each station's physical and social environment following a model described by the authors [6], by type of organisation (multiple or single actors); and by the context of the stations (socio-economic, land use variables, criminogenic environments, indicated by crime rates in the surrounding area from official crime statistics). The analysis was split into *descriptive* (frequencies and cross tables) and *confirmatory* (regression models). Given that there were a large number of variables and aiming at obtaining parsimonious models, we used exploratory data analysis and hypothesis testing (frequencies and cross-table correlation) to select a set of variables that could best indicate the characteristics of passengers and stations to explain both victimisation and fear. For instance, a set of variables was excluded after testing the bivariate correlation between independent variables ($r \geq 0.6$). Examples were station size and average daily passengers (correlated with the presence of restaurants,

for instance, which was kept in the model) and income and education. Given the fact that we have limited information about the internal environmental conditions of the train wagons, our analysis is focused on the safety conditions of the stations and on the way to them.

For the logistic regression models (a dichotomous dependent variable for 'being victimised' and 'poor safety perceptions' = 1 was created), the 5% level of significance was considered, and in the case of a statistically significant result, the probability value (p-value) was provided. Two sets of models were used as a basis for victimisation and safety perceptions. The independent variables are composed of individual attributes of the passengers and the characteristics of the railway station and surrounding areas or the way to it. Examples of individual attributes are gender, gender status, place of birth, travel times, frequency of use of trains, and whether the respondents were victimised in the preceding five years. Among the station's characteristics, the models include variables that characterise the station (such as illumination), as well as the location of the station and its surroundings (such as whether the station is perceived as 'isolated', and whether there is a presence of open drug markets). In the first victimisation model, we included aggressive panhandling. Previous victimisation was included as an independent variable in the models of safety perceptions.

3 Results
3.1 The victimisation and safety perceptions of train passengers

Among the passengers who answered the questionnaire, 13.8% (*N* = 519) declared they had been victimised when travelling by train in the last five years – the incident may have happened on the way to the station, at the station, or on the train. Almost half of the incidents mentioned by passengers took place on the way to the station (46.7%), and one-third happened at the stations (33.8%), whereas the fewest incidents occurred while on the train (19.5%). The stations are not similar to each other, but they do share commonalities. Figure 2 provides examples of the different types of environments found in the stations. First, clear signage and automatic ticket purchasing points located in a single location in the station (a), an unobstructed overview from the platform but dark tunnels (b) and lastly, the empty platform of an isolated station in the outskirts of a rural municipality during daytime in winter (c).

Women were more likely to be victimised during the trip (14.0%) than men (9.2%), but passengers who identify as LGBTQI+ or non-binary were largely more victimised (21.6%) (Chi-Square = 26.074, df = 2, *p* < 0.001). Moreover, young people up to 29 years old were more victimised (17.2%) than older age groups (for example, 4.9% were

Fig. 2 The environment of railway stations: **a** Accessible travel information (RTI), clear signage and automatic ticket purchasing point located in a single location, **b** unobstructed overview from of the platform but dark tunnel, **c** isolated station in the outskirts of rural municipality. Source: Authors

victimised among those 60 years old or older), and young people up to 18 years old reported even more experiences of victimisation (20.8%). There are also noticeable relationships between victimisation and certain situational conditions. For example, 19.3% of passengers with reduced mobility were victimised compared to 12.6% of those without (Chi-Square$=5.615$, df$=1$, $p=0.018$). The most common offences reported by respondents were crimes of a sexual nature, such as sexual harassment or stalking.

As many as 34.2% ($N=1{,}148$) of respondents experienced poor safety perceptions when travelling by train. Passengers are anxious about being victims of theft (21.7%), assault (20.9%), or robbery (19.1%). People who travel in the evening or at night-time declare that they are more fearful (39.2%) than those who travel during the daytime (28.9%) (Chi-Square$=39.117$, df$=1$, $p<0.001$). Women and LGBTQI+ or non-binary people experience poor perceptions of safety, and the contrasts are especially evident when looking at crimes such as sexual harassment and stalking where the differences are amplified. Among those who declared a poor perception of safety, an overwhelming 91.8% felt unsafe in the tunnel at the station. Railway tunnels can vary, some are partly above ground and run through a hill, station or roads, with distinct portals at both ends. Keep in mind that the quality of the light of tunnels can vary during the day, and some may be more noticeable than others, based on their design and location (see an example of the tunnel in Fig. 2 (b). Pedestrian bridges near railway stations can be perceived as dangerous. Both tunnels and bridges are designed to enhance accessibility and improve the flow of foot traffic between different parts of the city. Keep in

mind that specific examples of tunnels and bridges may vary depending on the city and station.

There is a mismatch between the location of where passengers were victimised and where they declare feeling unsafe (Fig. 3). While half the incidents happened on the platform, on the train, or on the way to the station, the tunnel is where most passengers felt unsafe, as well as places around the station such as the bus terminal and car park where not many of the incidents took place.

3.2 Modelling victimisation and safety perceptions

Tables 2 and 3 show the results of the modelling for passengers' victimisation and safety perceptions. The variables that are common in all models are the presence of drug use/markets in the surroundings of stations and travelling during night-time, and among the individual characteristics, having a university education, which is an indication of socio-economic status. Personal characteristics of the passengers turned out to be more often significant when it comes to explaining the likelihood of a passenger being victimised in transit than the variables that indicate the quality of the stations and their surroundings (Table 2). Conversely, more of the variables that indicate the station's environment are significant in the models that explain the likelihood of passengers' perceived lack of safety. In sum, individual characteristics are more important when it comes to explaining the likelihood of victimisation than environmental factors. Passengers' safety perceptions are better estimated by the environmental conditions of rail-bound settings, by the characteristics of the transit environments that they see, including the underlying organisational conditions of the station (number of operators, CCTV, maintenance, criminogenic conditions, etc. (Table 3).
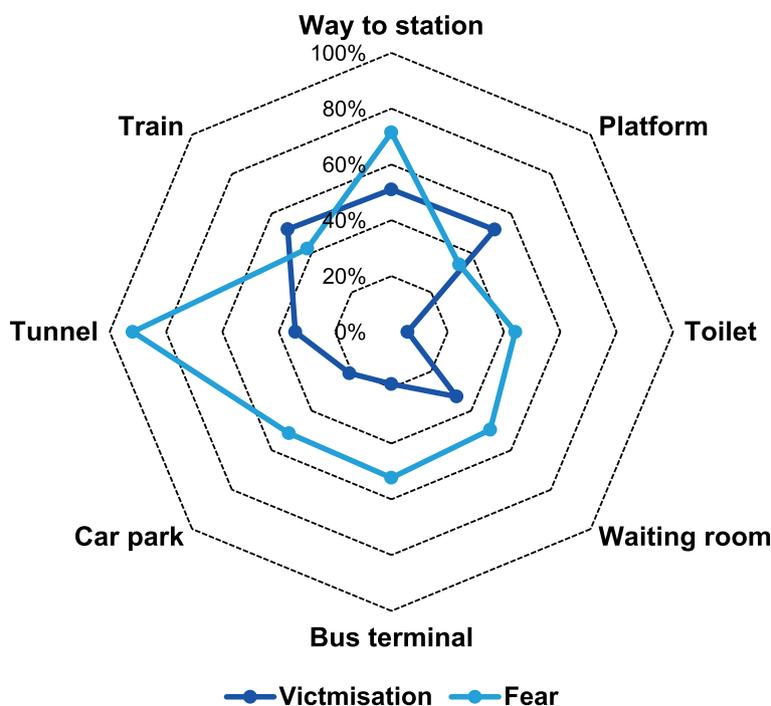
Fig. 3 Percentage of those who were victimised (dark blue), percentage of those who declare that they feel unsafe during the trip (light blue), $N_{victimisation} = 519$; $N_{fear} = 1,148$. Note that a passenger might be victimised/fearful in multiple places. Source: Authors

Safe stations share commonalities. The presence of various stations' amenities and attributes plays a crucial role in a safe station. Stations housing restaurants or cafés (which is indicative of relatively larger stations) display a reduced likelihood of victimisation in the station (OR = 0.532, $p = 0.014$), suggesting their potential role in enhancing security by increasing the level of surveillance. Another important result is that the number of CCTVs, the number of station operators, illumination, the presence of staff at the station, and good management/maintenance have a significant impact on crime occurrence or safety perceptions. The presence of toilets and the passengers' ethnic background were variables that were not significant in the models (at the 5% level at most).

3.3 Passengers' victimisation

In rail-bound settings, drug use/open drug markets in the station area, stations located in isolated areas, lack of staff at the station, and the presence of restaurants or cafes are all important factors affecting victimisation. A station that is isolated increases the odds of victimisation in the total victimisation model (Table 2, model a), which highlights the importance of considering the station's proximity to other facilities and populated areas. The presence of drug-related activities is a significant concern and increases the risk of victimisation by up to two times (Table 2, model b). There is also a significant link between

a lack of staff and a higher likelihood of victimisation within the station (OR = 1.787, $p = 0.001$). The presence of a restaurant or café in the station increases surveillance and makes the station safer (OR = 0.532, $p = 0.014$). The passengers' individual characteristics (such as age and whether they travel at night-time) were more important when it comes to explaining the likelihood of being victimised. Passengers who identify themselves as having reduced mobility are 1.8 times as likely to be victimised as those who are fully physically able ($p = 0.018$). Those travelling at night are 1.6 times as likely to be victimised as those travelling during the day ($p < 0.001$), and frequent passengers (using transport more than four times per week) also displayed an increased risk of being victimised. Women are 1.5 times as victimised as men ($p = 0.003$), and so are younger passengers (1.7 times as likely as older passengers) ($p = 0.018$). Passengers who do not have a car available for their travel and therefore have no choice but to use public transport or to walk/bike are 1.3 times as likely to be victimised as those who are not transit captives ($p = 0.047$). For some transit captives, also called captive riders, transit may be their only means of motorised transportation [67].

3.4 Passengers' safety perceptions

Previous victimisation has an impact on safety perceptions of passengers. Passengers who were previously

Table 2 Logistic regression results of Y=Passengers' victimisation (a), in the station (b) and on the way to the station (c)

Y=Victimised=1, otherwise, 0		Victimisation (a) N=313				Victimisation in the station (b) N=195				Victimisation on the way to the station (c) N=231			
		OR	C.I. 95%		Sig	OR	C.I. 95%		Sig	OR	C.I. 95%		Sig
Individual characteristics	Woman	**1.547**	**1.166**	**2.053**	**0.003**	1.222	0.870	1.718	0.247	1.547	1.166	2.053	0.061
	Young (under 18)	**1.696**	**1.095**	**2.627**	**0.018**	1.636	0.954	2.807	0.074	1.696	1.095	2.627	0.235
	LGBTQI+ /Non-binary/Other	1.368	0.756	2.476	0.301	0.645	0.276	1.508	0.312	1.368	0.756	2.476	0.463
	Foreign-born	1.125	0.740	1.709	0.581	1.054	0.615	1.807	0.847	1.125	0.740	1.709	0.672
	Frequent passenger	**1.363**	**1.042**	**1.782**	**0.024**	**1.701**	**1.231**	**2.350**	**0.001**	**1.363**	**1.042**	**1.782**	**0.002**
	Travel during night-time	**1.621**	**1.252**	**2.098**	**0.000**	**1.728**	**1.248**	**2.392**	**0.001**	**1.621**	**1.252**	**2.098**	**0.000**
	University education	**0.701**	**0.537**	**0.917**	**0.009**	**0.657**	**0.472**	**0.916**	**0.013**	**0.701**	**0.537**	**0.917**	**0.003**
	Reduced mobility	**1.776**	**1.103**	**2.857**	**0.018**	**2.275**	**1.324**	**3.908**	**0.003**	1.776	1.103	2.857	0.203
	Transit-captive	**1.293**	**1.004**	**1.665**	**0.047**	1.277	0.934	1.746	0.126	1.293	1.004	1.665	0.213
Station characteristics	Restaurant/café	0.851	0.575	1.261	0.423	**0.532**	**0.322**	**0.880**	**0.014**	0.851	0.575	1.261	0.249
	Toilet (pay)	1.082	0.725	1.615	0.700	1.605	0.954	2.700	0.075	1.082	0.725	1.615	0.253
	Poor illumination	0.843	0.641	1.109	0.223	0.993	0.711	1.388	0.969	0.843	0.641	1.109	0.509
	No. of CCTVs	0.919	0.785	1.074	0.288	1.055	0.870	1.279	0.584	0.919	0.785	1.074	0.192
	No. of operators	0.996	0.893	1.110	0.938	0.926	0.811	1.057	0.254	0.996	0.893	1.110	0.615
	Lack of staff	1.189	0.919	1.539	0.187	**1.787**	**1.288**	**2.480**	**0.001**	1.189	0.919	1.539	0.135
	Poor maintenance	1.133	0.849	1.511	0.396	1.208	0.858	1.701	0.278	1.133	0.849	1.511	0.358
Station location & area characteristics	Tunnel	1.377	0.986	1.925	0.061	1.207	0.790	1.845	0.385	1.377	0.986	1.925	0.175
	Isolated station	**1.334**	**1.012**	**1.759**	**0.041**	1.259	0.898	1.766	0.181	1.334	1.012	1.759	0.106
	Drug use/selling at station	**1.573**	**1.203**	**2.057**	**0.001**	**2.062**	**1.485**	**2.864**	**0.000**	**1.573**	**1.203**	**2.057**	**0.000**

OR Odds ratio, *CI* Confidence interval, *Sig p*-value, Statistically significant at the 5% level at most. Significant values are in bold

Table 3 Logistic regression results of *Y* = Poor safety perception (a), in the station (b) and on the way to the station (c)

Y = Poor safety perception = 1, otherwise, 0		Poor safety perception (a) *N* = 871			Poor safety perception in the station (b) *N* = 637			Poor safety perception on the way to the station (c) *N* = 648		
		OR	C.I. 95%	Sig	OR	C.I. 95%	Sig	OR	C.I. 95%	Sig
Individual characteristics	Woman	**2.075**	**1.664** **2.587**	**0.000**	**1.847**	**1.451** **2.352**	**0.000**	**2.502**	**1.961** **3.193**	**0.000**
	Young (under 18)	0.912	0.610 1.365	0.655	1.047	0.689 1.590	0.829	0.976	0.646 1.474	0.909
	LGBTQI+/Non-binary/Other	**3.103**	**1.920** **5.014**	**0.000**	**3.396**	**2.076** **5.554**	**0.000**	**3.274**	**2.000** **5.360**	**0.000**
	Foreign-born	0.896	0.637 1.260	0.528	0.847	0.582 1.233	0.386	1.063	0.744 1.519	0.738
	Frequent passenger	**1.342**	**1.078** **1.671**	**0.008**	1.180	0.934 1.492	0.165	1.247	0.991 1.569	0.060
	Travel during night-time	**1.590**	**1.304** **1.938**	**0.000**	**1.420**	**1.146** **1.759**	**0.001**	**1.692**	**1.369** **2.091**	**0.000**
	University education	**0.659**	**0.532** **0.815**	**0.000**	**0.703**	**0.561** **0.883**	**0.002**	**0.597**	**0.478** **0.747**	**0.000**
	Reduced mobility	1.199	0.775 1.857	0.415	1.230	0.782 1.937	0.370	0.998	0.633 1.572	0.992
	Victim of crime	**4.985**	**3.721** **6.677**	**0.000**	**4.656**	**3.538** **6.129**	**0.000**	**3.416**	**2.608** **4.473**	**0.000**
	Transit-captive	0.993	0.809 1.219	0.946	0.993	0.797 1.237	0.953	1.071	0.864 1.329	0.531
Station characteristics	Restaurant/café	**0.603**	**0.442** **0.824**	**0.001**	**0.641**	**0.459** **0.897**	**0.009**	**0.607**	**0.437** **0.841**	**0.003**
	Toilet (pay)	1.045	0.763 1.431	0.786	1.159	0.822 1.633	0.399	0.925	0.665 1.288	0.646
	Poor illumination	1.103	0.889 1.367	0.373	1.060	0.844 1.332	0.617	**1.263**	**1.010** **1.580**	**0.041**
	No. of CCTVs	**0.837**	**0.739** **0.947**	**0.005**	**0.829**	**0.727** **0.946**	**0.005**	0.911	0.799 1.038	0.162
	No. of operators	**1.116**	**1.025** **1.217**	**0.012**	**1.135**	**1.035** **1.244**	**0.007**	1.059	0.967 1.159	0.220
	Lack of staff	**2.477**	**2.023** **3.033**	**0.000**	**2.454**	**1.973** **3.052**	**0.000**	**2.036**	**1.644** **2.521**	**0.000**
	Poor maintenance	**1.452**	**1.151** **1.832**	**0.002**	**1.578**	**1.240** **2.008**	**0.000**	**1.288**	**1.012** **1.640**	**0.039**
Station location & area characteristics	Tunnel	**2.030**	**1.562** **2.637**	**0.000**	**2.118**	**1.583** **2.833**	**0.000**	**2.205**	**1.655** **2.937**	**0.000**
	Isolated station	1.060	0.848 1.325	0.608	1.127	0.891 1.424	0.318	1.227	0.975 1.545	0.081
	Drug use/selling at station	**1.852**	**1.496** **2.292**	**0.000**	**2.024**	**1.618** **2.533**	**0.000**	**1.752**	**1.402** **2.190**	**0.000**

OR Odds ratio, *CI* Confidence interval, *Sig p*-value, Statistically significant at the 5% level at most. Significant values are in bold

victimised in transit are almost five times as likely to declare that they feel unsafe ($p < 0.001$) as those who were not victimised. Similarly, those who were previously victimised in transit are 3.4 times as likely to declare that they feel unsafe on the way to/from the station ($p < 0.001$) as those who were not. Among other individual characteristics, Table 3 shows that those passengers that identify as LGBTQI+/Non-binary/Other run a 3.4 times higher likelihood of feeling unsafe at the station and are 3.3 times as likely to declare that they feel unsafe on the way to or from the train ($p < 0.001$) as the rest of the sample. Women too declare feeling more unsafe than the rest of the population (more than double the likelihood of men), especially on the way to the station where they are 2.5 times as likely to feel unsafe, perhaps because they were also more victimised on the way to/from the station (1.5 times as likely to be victimised as men (but note $p = 0.061$)). Additionally, in rail-bound settings (the characteristics of the stations and the surrounding areas), passengers who use tunnels are up to 2.0 times as likely to feel less safe as those who do not ($p < 0.001$). Passengers who experience a lack of staff at stations are 2.5 times as likely to feel unsafe at the station and twice as likely on the way to/from the station. Drug use/open drug markets

around the station double ($p < 0.001$) the odds of passengers feeling unsafe at the station (note that drug use/open markets are highly correlated with criminogenic environments measured by crime rates).

3.5 The station and the way to the station

The disparity in passengers' victimisation and safety perceptions between the station and the journey to the station can be justified by recognising the distinct environments and factors at play. For victimisation on the way to the station, only the conditions of crime around the stations are significant when it comes to explaining the variation of victimisation out of several environmental factors. However, the victimisation pattern at the station varies according to several conditions at the station, such as the presence of restaurants, a lack of staff, and the presence of drug selling around the station (Table 2). For safety perceptions, several variables of the environment of the stations turned out to be significant to explain the situation both in the station and on the way to it, namely drug selling around the stations, the presence of tunnels, poor staff, and the presence of cafés/restaurants. Poor lighting turned out to be significant only in the model to explain safety on the way to the station (Table 3).

3.6 Recommendations according to train passengers

Train passengers were asked to point out what they think is needed to make the train stations safe. Passengers were offered a list of items covering the physical and social environment of the stations; they were allowed to select multiple items. The way passengers were asked (ranking order of the suggestions) did not affect their answers, see Ceccato et al. [8]. The answers were similar regardless of the experience of the passengers and the order of the suggestions. Figure 4 shows that the majority of suggestions from train passengers include improvements in formal and informal social control at the stations. This means more staff at the station, CCTV at the station, more police officers/security guards that can patrol the station, and, on the train, CCTV but also a help button in the train and the station in case something happens. Good-quality illumination is the fifth most important aspect ranked by passengers. About a third of the suggestions recommend better maintenance of the station environments followed by other issues such as train frequency, and more information or new ways to call for problems along the trip, such as apps or call lines. These recommendations are also in line with more than 140 studies reviewed by Ceccato et al. [7].

4 Discussion of results

Although one-sixth of the passengers have been victimised when travelling by train in the last five years, more than a third experienced poor safety perceptions when travelling by train. The findings discussed in the previous section help us respond to this study's research questions. We confirmed previous research that shows that both victimisation and fear vary by type of environment at the stations and during the trip ([10, 21, 44]), but victimisation is less dependent on the conditions of the stations than passengers' safety perceptions. This can be explained by the fact that fear is more often associated with particular visual signs, such as poor maintenance, than victimisation. In the Swedish case, it can be associated with aggressive panhandling, open drug markets around the station, or just vandalism. The effect of poor management and maintenance is well documented in the international literature. It may reflect poor cleaning practices in and around transit nodes [37, 40], but may also be associated with the lack of staff. Note that all models indicate that a lack of staff in the station makes passengers feel left behind, which reduces their safety perceptions and is responsible for explaining the greater likelihood of victimisation at the station.

More interestingly, while half the incidents happened on the platform, on the train, or on the way to the station, the tunnel to the station was where most passengers felt unsafe (perhaps because of the feeling of being
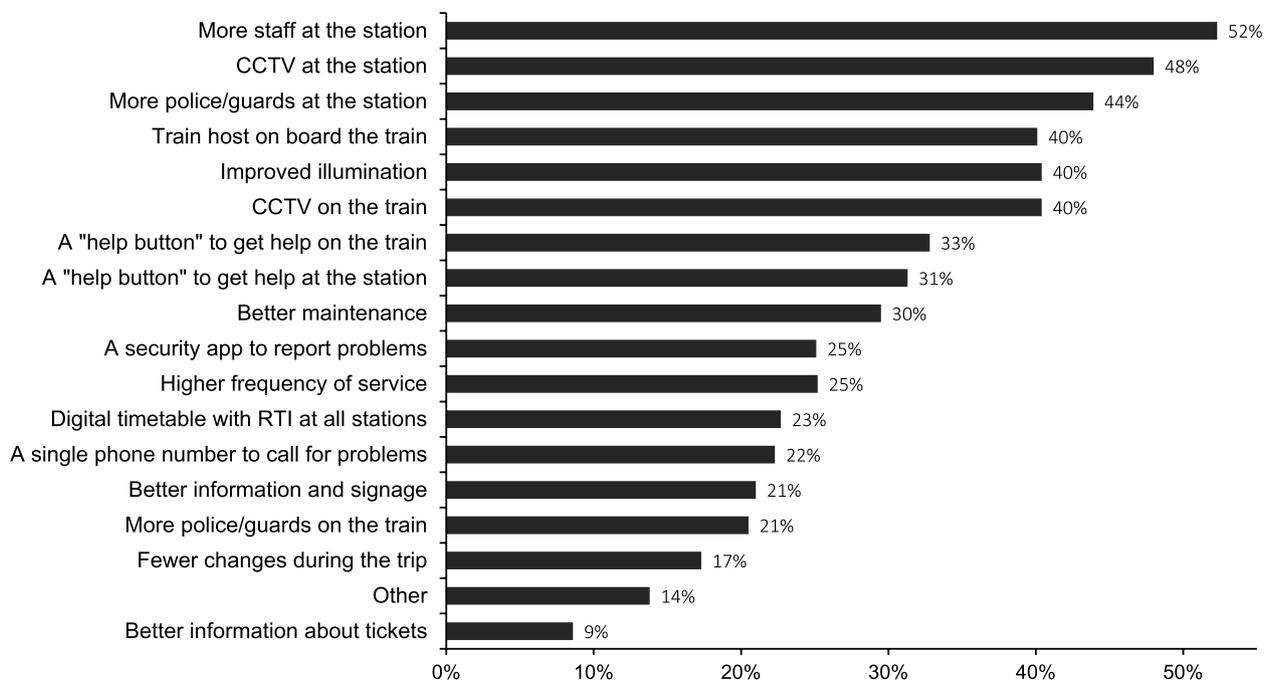
Fig. 4 Can train stations be made safer? Recommendations from survey (*N* = 3,227 passengers). Source: Authors

entrapped, sometimes with poor illumination), as well as in places around the station such as the bus terminal and car park where not many of the incidents took place but might be felt to be isolated or unguarded. In isolated places, passengers feel themselves becoming easy targets for criminals [5] and they therefore feel unsafe, even when they are not victimised there. Typically, the literature points out unsafe places in stations such as long corridors, often with sharp corners and restricted sight lines [17, 24]. A recent systematic literature overview indicates that impaired visibility is associated with a fear of crime, because having control of where others are and the capacity to see and be seen by others increases the confidence of passengers [58].

It is important to recognise that the literature is quite definite about the complexity of transit environments and their impact on safety. Our findings show that it is not possible to find a single "physical (or social) characteristic of these environments" that, if tackled, will solve a safety problem. However, we recognise that a safe station provides a sense of control, with people around, both staff and passengers. They tend to be larger (larger urban areas), associated with good natural surveillance and illumination, but less associated with the selling of drugs at the station or close to it.

Passengers' victimisation and safety perceptions are gender-specific (e.g. [38]), but other particular individual factors affect transit safety. These findings signal the need for a more nuanced perspective on transit safety, one in which, for instance, disability (expressed here in the form of passengers with "reduced mobility") stands on its own, not only as a context or a nuance of gender or age oppression [20]. Focusing on disability in particular, Watermeyer and Swartz [62] warn us of 'selective' intersectionality use, where only certain forms of exclusion are considered to be caused by race and gender. The same reasoning could be applied to sex and gender status with clear implications for practice. Our findings show that particular groups have safety needs, but most transport operators around the world do not think they should put specific programmes in place to address these needs. Back in the 2000s, Loukaitou-Sideris and Fink [38] suggested that only a handful of agencies had programmes that targeted the safety and security needs of women, and fourteen years on, the situation is not different.

Our findings are quite definite about the fact that individual characteristics are more important when it comes to explaining the likelihood of *victimisation* than environmental factors. This makes sense since individual factors such as frequency of use of public transportation also affect victimisation. However, passengers' *safety perceptions* are better estimated by the environmental conditions of transit settings, and by the characteristics of the

environments that one sees and senses. This suggests that how long people spend in transport settings has a greater impact on the risk of victimisation (it links to routine activities, see Vaughan et al. [61] who assess how long people spend in a particular setting, using activity-based crime rates). Other previous research also indicates that the time spent on public transport (often linked to age, gender, socio-economic status and access to a car, etc.) is linked more to victimisation, while perceptions of safety are driven by visual cues from the transit environment and neighbourhoods [49], rather than the incidence of victimisation itself, see also Kang et al. [28].

We also found that passengers' characteristics do not affect victimisation or safety perceptions in the same way; namely, some of these individual characteristics of passengers affect only victimisation, others only fear, and some both or none. Being LGBTQI+/Non-binary/Other affects one's declared perceived safety but not one's victimisation, while disability and age impact the likelihood of being victimised but do not affect passengers' fear. These findings may not be a surprise since the mechanisms that affect victimisation may not necessarily impact the perception of safety [51]. Given their significance, these individual factors should be given priority when defining safety intervention measures in Stockholm's transit environments, avoiding one-size-fits-all solutions.

4.1 Conclusions and recommendations for future research and practice

At the beginning of the article, we pose the question: What makes a railway station safe? Our results show that while individual characteristics play a significant role in train passengers' victimisation, train passengers' safety perceptions are more influenced by the station's environment and surroundings. Certain individual traits might increase vulnerability to victimisation, but addressing these directly might be challenging from a planning perspective. On the other hand, passengers' perception of safety is greatly shaped by the environment of the station, and this is where intervention becomes possible. The presence of amenities like cafés, restaurants, or kiosks that facilitate natural surveillance seems to positively impact safety perceptions. Formal surveillance (personnel in the stations or CCTV cameras) also has a positive impact on the perception of security. Other factors that contribute to this include well-maintained stations – what passengers see (and do not see) affects safety – comfortable and well-maintained waiting areas, as well as clear signage and information that helps passengers feel secure.

Note that this is the first time in Sweden that multiple data sources were collected and put together to estimate

passengers' victimisation as well as their safety perceptions in railway transit environments. Although they are a good reference for this study, findings from previous studies on underground stations in Stockholm, the capital of Sweden, are not comparable to those from this study for several reasons. While previous studies used different data sources and were based on the environments of fairly homogenous stations in terms of the size of passenger flow and location, this study looks at the conditions in train stations of varied sizes across the rural–urban continuum: seven stations have more than 2,000 daily passengers, 18 stations have fewer than 500 daily passengers and 22 stations have 500–2,000 daily passengers, covering a variety of rural contexts, which is unique in national and international literature.

Moreover, recognising the environment as a crucial element in shaping perceptions of safety has significant implications for the development of policies and the upkeep of transit settings. It is common for smaller stations with no staff or personnel to be perceived as less safe, which creates a challenge for safety interventions since staff cannot be in all stations and much less in the smaller ones. The station's surroundings and its location are also a crucial point. Stations where open drug sales or drug use take place often tend to be perceived as unsafe. Additionally, tunnels, bridges, paths, and certain areas around stations have been identified as negatively impacting safety perceptions, necessitating innovative design and planning approaches. This situation also raises further questions about the sources of discomfort and those who feel endangered. It has been observed that certain passengers feel more impacted by the presence of panhandlers than others. The issue of panhandling introduces complex ethical dilemmas concerning the right to occupy public spaces; in certain municipalities, panhandling is a crime while in others, it is not. These environments have become 'grey zones' in the planning and governance of public places because these places often lack coordinated actions from place managers (transport operators, municipalities, security companies, and other relevant actors) who fail to provide an accessible and safe environment for passengers and transients. None of these groups feel committed to delivering services and protection beyond their area of jurisdiction and responsibility.

Although there are clear links between the environment and passengers' safety perceptions, our results show that the answer to this question depends on the interaction between passengers' characteristics and the features of the environments experienced and perceived by the passengers in railway environments. A station can be crime-free, but if passengers still perceive it to be unsafe, then they most likely will avoid it for reasons other than the station's criminogenic conditions (e.g., if they are anxious about buying train tickets in automatic booths with no help from staff or if they notice that nobody is in control of the station, expressed by poor maintenance practices). Previous research on airports has shown that passengers' safety is dependent on the profile of passengers in combination with the perception of a lack of staff (Ceccato and Masci, 2017). Therefore, future research should explore the interaction effects between for example passengers' characteristics and the lack of staff at stations/poor maintenance.

In times of digitalisation and automation of travel services, several passengers might feel uneasy if they cannot plan their trip safely. This demands tailored policies that satisfy the safety needs of these specific groups of transit passengers. According to the results of our study, women and those who identify as LGBTQI+/Non-binary/Other should be prioritised, as well as those who travel during the night-time and those with reduced physical mobility. Although many of the problems and their solutions are not generic and need to be tailored for each environment with different user groups invited to be involved in planning, it is however clear that passengers do want to be able to get in touch with someone if something happens, or just know they can do so, if something should happen.

Safety conditions at transport nodes are not the same as those experienced or perceived on the way to them. If policies are to be tailored to attend to the safety needs of those who declare they are most in fear, "fixing" the problem of victimisation does not solve issues related to poor perceived safety. As initially hypothesised, passengers who were previously victimised declare that they feel less safe than those who were not. This is an indicator that crime in transit environments is an issue still greatly underreported because there is no central system to register these incidents that happen during the trip. The fact that there is no central system that collects incident data means that so far interventions carried out by safety experts and planners are not evidence-based. Although a few operators have created their own databases, they are limited to particular stations or are rarely shared among other operators, which makes it difficult to generalise the problems and solutions for other stations throughout Sweden. Using police statistics to understand what happens inside the stations can lead to misconceptions given the fact that only major incidents of crime are reported to the police. Minor events of incivilities and/or public disorder that are not crimes but that directly affect people's safety perceptions can be a problem when not identified. Note that in other rail-bound stations, between 80 and 90% of incidents recorded by passengers and personnel are not crimes [6]. Data provide a solid foundation for making informed decisions in public transportation. The need for a centralised system for recording incidents is

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fundamental to creating a basis to better plan the safety of train passengers.

Addressing the mismatch between perceptions and experiences of victimisation in stations requires specific policies, embracing a set of more long-term interventions that go beyond the station. To prevent a disparity between crime and persistent fear, policymakers should prioritise community involvement in the design and evaluation of prevention measures. Creating a sense of safety through well-lit spaces and effective communication can bridge the gap between public perception and the actual crime situation, fostering a safer environment for passengers. Policymakers should focus on improving coordination between stakeholders and more transparency; creating databases with accurate and updated data about passenger victimisation and safety. This entails dedicating resources to customised strategies that address the specific safety requirements of different passenger groups, thereby ensuring the sustainability of mobility for all in the long term.

Authors' contributions
Vania Ceccato conceptualised the study, secured funding for the project, collected data, performed the analysis (descriptive and modelling), and wrote and edited the article. Gabriel Gliori collected the data, curated the data, performed data analysis (descriptive and modelling) and wrote sections of the analysis. Catherine Sundling secured funding for the project, collected data and wrote the article.

Availability of data and materials
The dataset is not available for sharing.

Declarations

Consent for publication
Following approval by the Swedish Ethical Review Authority (Ref. 2021-06393-01), data was collected between May and September 2022.

Competing interests
The authors have no competing interests to report.

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