Applied Spatial Analysis and Policy (2023) 16:851–871
https://doi.org/10.1007/s12061-023-09507-0

Familiar Strangers and Crime at Transit Stations: Is Crime Lower at Train Stations Where Familiar Strangers are Present?

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Received: 22 September 2022 / Accepted: 1 February 2023 / Published online: 10 February 2023
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Abstract

Familiar strangers—individuals related through regular and repeated visual encounter occurring without verbal interaction—may reduce the risk of crime at places by increasing guardianship and internal motivation for norm compliance. This study examines the association between *familiar stranger* presence and incidents of theft and disorder at train stations using transit smart card and crime data for 22 stations across a six-month period. Familiar strangers are operationally defined as individual transit cards that are co-present within a 30-min temporal window on more than two occasions across a one-month period at a given train station. We apply logistic regression to estimate the likelihood of disorder and theft crimes within a 400-m radius of train stations controlling for station environmental features, co-located facilities and neighbourhood socio-demographic characteristics. Our results show that the impact of familiar strangers on crime (disorder and theft) at train stations is moderated by the neighbourhood socio-demographic context. This may suggest that macro-level norms of informal social control are important for determining crime at micro-places such as transit stations. The findings also indicate that urban design and transport policies require greater flexibility to enable intra-network variability in station design and formal security to enhance ridership.

Keywords Familiar strangers · Train station · Crime · Guardianship

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Introduction

Safe, reliable public transit networks are an essential element of sustainable cities (Ceccato & Newton, 2015). As the global trend towards urbanisation continues to densify cities, the need to motivate commuters to transition from car dependence to public transit use increases in urgency. Perceived crime and safety concerns are a major hindrance to public transit ridership (Tyrinopoulos & Antoniou, 2008). As primary nodes of mobility and population intersection, transit stations can facilitate opportunities for crimes by generating crowds in peak periods that obscure offender identity (Ceccato et al., 2015; Newton, 2014). Transit stations can also attract motivated offenders in non-peak periods to take advantage of unguarded stations to engage in vandalism, property damage and violent crime targeting isolated commuters. Thus, to increase passengers' perceived safety and motivate public transit ridership, it is necessary to uncover factors associated with crime at transit stations and identify potential mechanisms associated with lower crime risk.

Transit stations are considered criminogenic because their physical and social features generate and/or attract opportunities for crime (La Vigne, 2015; Loukaitou-Sideris et al., 2002; Newton, 2018; Zahnow & Corcoran, 2019). The criminogenic capacity of transit stations may be exacerbated by characteristics of the surrounding neighbourhood that act to undermine social cohesion and norms of informal crime regulation by residents and commuters from the local area (Newton & Bowers, 2007). Many of the features that make stations opportune crime settings are common across other *risky facilities* and include high population flow, limited lighting, unclear sightlines, crowding and the presence of vulnerable or unassuming targets (Clarke & Eck, 2007; Newton, 2004). Yet, somewhat unique to transit environs is the role of routine daily mobility in shaping commuters' perceptions of the environment and station crime opportunities (Zahnow et al., 2020). Given a large proportion of public transit ridership is centred around work and educational travel, it occurs with a high degree of spatial–temporal regularity which, over time, leads to familiarity with the station environ at a particular time of day (Jacobs, 1961). Studies find that transit station familiarity is positively associated with passengers' station awareness, perceived safety (Newton, 2014; Sampson et al., 1997), and their capacity to supervise the station environ, detect problems and intervene (Merry, 1981; Newton, 2014; Reynald, 2011). Further, when riders regularly attend a station at a particular time, they become familiar with faces of other regular commuters, a social phenomenon referred to as *familiar strangers* (Milgram, 1972). By removing anonymity, the presence of familiar strangers enhances internal motivation to comply with rules and social norms (Zahnow et al., 2020). This may reduce opportunities for crime.

Familiar strangers were first observed in public transit environs by Stanley Milgram in 1972. He described familiar strangers as individuals one frequently observes but does not verbally interact with (Milgram, 1972). Familiar strangers at transit stations, not unlike crime opportunities, emerge from spatial–temporal regularities associated with daily routines such as work and educational commutes (Leng et al., 2018). At the time, Milgram (1972) hypothesised that familiar faces at places might provide a form of consistent place demarcation in the

context of rapid urban regeneration and loss of familiar physical landmarks and place features that helped people "navigate" their daily lives and identify with places. After conducting a survey of train riders, Milgram found that despite lacking personal information to support close social bonds, familiar strangers felt a mutual responsibility towards one another. This suggests that greater familiarity among riders at stations may enhance perceived safety and help to reduce the likelihood of actual crime events by increasing both self-monitoring (Newton, 2014; Newton et al., 2014) and willingness to intervene or come to the aid of familiar others (Milgram, 1972).

Whilst the role of place familiarity has been recognised by empirical research, the study of familiar strangers and crime remains in its infancy (Newton, 2014; Reynald, 2011). Milgram's original study at a single station tells us little about the local socio-cultural contexts in which familiar strangers emerge and facilitate positive norms of reciprocity towards others. Nor has research considered the potential for patterns of familiar strangers to vary over time. This is largely due to poor data availability and computational challenges associated with the measurement of familiar strangers. Objective measurement of familiar stranger encounters requires the capacity to capture repeated co-presence of the same two individuals at a particular place over a period of time. Big data sources including mobile phone and smartcard travel data provide a new opportunity to measure the phenomena, but computational demands are very high given the size of the datasets and the need to search for repeat pairings among all cases within small windows of time (e.g. each 30 min window). For this reason, studies employing big data sources to measure familiar strangers are typically limited to examining the phenomena over a one-week period and operational definitions vary widely preventing generalisability and compilation of study findings.

In this study, we extend the current literature on familiar strangers and crime by using transit smartcard data to examine the impact of familiar strangers on the presence of theft and disorder at train stations over a *six-month period* (26 weeks). To achieve this, we focus on a single weekday (Wednesday) and a single weekend day (Saturday) to examine patterns of familiar strangers and crime at stations over 26 weeks. Drawing on crime opportunity theories and Stanley Milgram's concept of the familiar stranger, we hypothesise that the risk of crime at stations will be lower on days when the presence of familiar strangers is higher.

Background

Public Transit Stations as Risky Facilities

Public transit stations are considered criminogenic because they feature environmental characteristics that increase opportunities for crime. Transit stations, alongside other urban features including bars, shopping centres and schools, are defined as *risky facilities* because of their proclivity to facilitate crime (Clarke & Eck, 2007). The concept of risky facilities is underpinned by routine activity theory. Routine activity theory was introduced in 1979 and represents the first theoretical shift

away from the individual offender to focusing on the crime event (Cohen & Felson, 1979). From this perspective, crime occurs at places and times that facilitate motivated offenders and attractive targets coming together in the absence of a capable guardian. Specific places that routinely meet these criteria are referred to as risky facilities.

While transit stations broadly are considered *risky facilities* (Eck et al., 2007), some transit stations provide greater opportunities for crime than others. Physical and social features of the station and surrounding environ can influence crime risk (Ceccato et al., 2015; Newton, 2018; Zahnow et al., 2020). Crime at transit stations is higher at stations where lighting is poor and place management is absent (Liggett et al., 2004). The co-location of parking facilities (Loukaitou-sideris, 1999), bars (Newton & Bowers, 2007), schools (Adams et al., 2015) and parks (Newton & Bowers, 2007) can also increase opportunities for crime at stations by generating greater population flow at particular times of the day and days of the week. For example, train stations located nearby schools may generate crime opportunities in the afternoon as students congregate on stations to commute home (Adams et al., 2015). Stations located nearby bars are more likely to attract higher crime on evenings and weekends when intoxicated revellers provide vulnerable targets and/ or offenders (Adams et al., 2015; Newton & Felson, 2015).

Characteristics of the neighbourhoods in which transit stations are located further influence the propensity for crime to occur. Neighbourhood characteristics that undermine the capacity for residents and local commuters to exercise active guardianship (Reynald, 2009, 2010) including disadvantage, ethnic/racial diversity and residential mobility (Bursik & Grasmick, 1993), make transit stations in those areas more attractive crime targets. A study of crime at Los Angeles light rail stations found that stations located in disadvantaged neighbourhoods experienced higher levels of assault compared to those in wealthier areas and vandalism was higher at stations located in neighbourhoods characterised by low educational attainment (Loukaitou-Sideris et al., 2002). The authors interpreted the findings through a social diorganisation lens, suggesting that social disorganisation in the surrounding neighbourhood exacerbated the attractiveness of stations for motivated offenders due to low levels of informal guardianship in the surrounding area and reduced risk associated with offending (see also Ceccato et al., 2013; Irvin-Erickson & La Vigne, 2015 Vigne, 2015; Newton et al., 2015; Uittenbogaard & Ceccato, 2014).

Much of the current reseach on transit crime focuses on crime-facilitating physical and social features of the station environment common across all risky facilities. Unique to transit stations and yet to be fully explored is the role of daily regularity (Felson & Boivin, 2015; Zahnow & Corcoran, 2019) and resultant familiarity between commuters in altering opportunities for crime at stations. Familiarity with physical and social environs can enhance perceived safety and guardianship capacity by increasing awareness of the surroundings and ability to identify potential crime risk (Reynald, 2010). A growing body of evidence demonstrates the relationship between place familiarity and perceived safety (Chataway, 2020) and highlights that social ties further enhance this assocaition (Zahnow et al., 2021). Less is known about how light touch forms of social connection such as familiarity with faces of people at places, in the absense of intense social ties influence perceived safety and actual crime. We propose that *familiar strangers* can influence crime at stations by

increasing guardianship capacity of regular commuters with implications for perceived safety. When individuals visually recognise their fellow regular commuters they are better able to detect outsiders who may pose a crime threat (Reynald, 2010). Further, a sense of familiarity and awareness of others can activate a feeling of reciprocity between individuals which, in turn, can motivate willingness to act in the event of a crime or emergency situation to aid the other individual (Reynald, 2009). Finally, by reducing perceived anonymity, the presence of familiar strangers may enhance internal motivation to comply with rules and social norms, therefore deterring offending (Zahnow et al., 2020).

Familiar Strangers

The familiar stranger is someone you recognise by face but do not know by name. Milgram first investigated familiar strangers at transit stations in the context of rapid urban regeneration and changes in public places in 1960s America. He suggested that familiar strangers, arising naturally from the collective spatiotemporal regularities of human mobility such as the routine use of public transport (Leng et al., 2018), may help individuals navigate daily routines and identify with places amidst physically changing urban landscapes. After surveying commuters, he found that many recognised others by face and felt a sense of responsibility towards familiar strangers that they did not feel towards complete strangers. Despite the ubiquity of familiar strangers in daily life our knowledge of the social benefits this form of light touch sociality may accrue at places remains limited. Drawing on theories of crime, place familiarity and knowledge about guardianship it is reasonable to propose that a sense of familiarity with other commuters may enhance willingness to intervene (Felder, 2020; Reynald, 2010; Sampson et al., 1997) in the case of a crime event by stimulating a sense of awareness (Reynald, 2009), reciprocity and duty of care (Milgram, 1972). Yet, the extent to which this occurs may vary dependent on the social characteristics of the station neighbourhood and whether they support or undermine shared norms of informal crime regulation. While Jacobs (1961) purports the crime prevention benefits of *eyes on the street,* Reynald (2009) explains that actual intervention in the event of a crime problem is the precipice of crime guardianship. That is, while most people may inadvertently act as guardians through mere presence, few will actually do something in the event of a problem. Awareness of the environment and individual willingness to assist others *must* be supported by neighbourhood social cohesion and a belief that willingness to intervene for the common good is the accepted norm among local residents (Sampson et al., 1997) to motivate individuals to make the transition from awareness to active intervention (Reynald & Elffers, 2009). Thus, by enhancing guardianship *capacity* of regular commuters, familiar strangers may in turn facilitate lower crime at some stations, but this is likely to depend on the characteristics of the broader neighbourhood setting (Reynald, 2009; Sampson et al., 1997).

Contemporary studies of familiar strangers have extended Milgram's single-station exploratory survey to incorporate big data and examine the concept across transit networks in large cities including Beijing, Singapore and London (Leng et al., 2018; Liang et al., 2016; Paulos & Goodman, 2004; Sun et al., 2013; Zhou et al.,

2020) These studies focus on identifying spatial and temporal patterns of familiar strangers across transit networks, but the majority do not explore social implications of the phenomena. An exception is Zahnow et al. (2020), who examine the association between familiar strangers and theft at bus stops. Their results demonstrate that theft is lower at stations where familiar strangers are higher, supporting the link between familiarity and greater crime guardianship. Yet, their study also found that nuisance is positively associated with familiar strangers. This finding does not align with the guardianship hypothesis and suggests that the impact of familiarity on guardianship and crime may depend on crime type.

To date, a consistent, generalisable understanding of the potential for familiar strangers to reduce crime opportunities and enhance perceived safety has been hampered by data and computational limitations.[1] The computational capacity required to identity familiar strangers using big data sources, such as smartcard and mobile phone data, within smaller, discrete time windows that best align with the conceptual definition of the phenomena (e.g. less than one hour) is extremely large. Thus, operational definitions of the phenomena have been inconsistent and, in some cases, determined by capacity more so than conceptual accuracy. Further, scholarship has yet to examine the extent to which longer-term temporal factors such as seasonality and holiday events impact the emergence and maintenance of familiar strangers at stations. Time series analyses of other social phenomena, including crime, highlight the impact of seasons, weather, and calendar events on initiating temporary shifts in regular event patterns (Andresen & Malleson, 2013; Corcoran & Zahnow, 2021). Slow, incremental shifts in social processes and phenomena have also been documented over long periods of time, usually co-occurring with social demographic, environmental or political changes. Given the majority of current studies focus on one-week periods, they cannot assess the extent to which patterns of familiar strangers align with other social phenomena nor the potential for familiar strangers to provide social benefits such as crime prevention.

To extend on previous studies that have examined familiar strangers over a one week period (Leng et al., 2018; Liang et al., 2016; Sun et al., 2013; Zhou et al., 2020), in this study we focus to one representative weekday and one representative weekend day and examine the phenomena over a longer time frame of six-months (26 weeks). We select Wednesday ($N=26$ Wednesdays) as the representative weekday as it best represents the average of the five weekdays in regard to patterns of crime and familiar strangers. We select Saturday ($N=26$ Saturdays) as the representative weekend day. We adopt an operational definition of familiar strangers that directly reflects the conceptual understanding of the phenomena. That is, we define familiar strangers as any pair of transit riders with more than two encounter events within a one month period. An encounter event is defined by a co-location instance

[1] Existing familiar stranger studies measure the phenomena using a limited number of candidate days because of the computational demands. These candidate days are a deliberate selection to minimise computational complexity; a naïve approach of searching a dataset for interactions can easily result in algorithms that result in exponential increases of computation time as the number of trips increases.

between two transit smartcards entering (touching-on) the same train station within a dynamic[2] 30-min timeframe. We then consider the extent to which familiar strangers, as a percentage of daily commuters, at stations is associated with crime.

Methods and Data

Study Site

The study context is Brisbane; the second-fastest-growing metropolis in Australia (ABS, 2020). During the study period from July 15th 2015 to 12th January 2016, the Brisbane commuter train network comprised of 125 stations connected via seven train lines. In this study we focus on 22 train stations located on a single, commuter train line in the Brisbane city transit network.[3] We purposively selected this train line because it connects a relatively small number of stations. This limits the computational demand of measuring familiar strangers over a six-month period. Stations along the selected commuter line are representative of those throughout the broader transit network featuring open-air platforms. All platforms are equipped with CCTV and lighting, but co-located facilities (e.g. bars and shopping centres) and the socio-demographic characteristics of station neighbourhoods vary. Passengers travelling on the Brisbane city transit network pay for fares using a smartcard system (Go Cards) operated by Translink, a division of the Queensland Government Department of Transport and Main Roads (Translink, 2020). Over 86% of passengers on the Brisbane transit network pay for fares using the smartcard system (Translink, 2016). Trips are recorded when passengers touch 'on' and 'off' as they alight and depart train stations, buses, or ferry terminals.

Data and Variables

This study draws on data from three sources: (1) smartcard data (Go Card) from Translink; (2) crime data from the Queensland Police Service and; (3) census data from the Australian Bureau of Statistics.

Dependent Variable

Our dependent variables are drawn from the Queensland Police Service crime data 2016. In this study we focus on theft and nuisance offence crimes as the dependent variables. Our measure of theft is a dichotomous variable that indicates the presence of one or more incidents of theft in a station environ on a given day over the six-month period (0 = no theft; 1 = theft offences recorded). Similarly, our measure of nuisance crime is a dichotomous variable that indicates the presence of one or more

[2] Explained in greater depth in the Methods section.

[3] Our site does not encapsulate the two central city stations as these are transit hubs and operate as both train and bus stations.

nuisance offences on a given day in each station environ. Nuisance offences include property damage, public nuisance, and drug offences (but exclude drug trafficking/manufacturing). We define the station environ as a 400-m radius from the station centroid (Groff & Lockwood, 2014; Haberman & Ratcliffe, 2015; Zahnow & Corcoran, 2019). The 400-m buffer represents a distance that commuters are willing to walk to public transportation (Calthrope, 1993; Nelessen, 1994). Research on risky facilities also notes that facilities can have a positive influence on crime within a quarter mile radial buffer (McCord & Ratcliffe, 2007).

We selected theft and nuisance offences as the focus of study because scholarship suggests that offences involving a person victim (i.e. theft) and those targeting property or victimless offences (i.e. nuisance) will be differentially impacted by the presence of other passengers and familiar strangers (Zahnow & Corcoran, 2019; Zahnow, et al., 2021). For example, Zahnow and Corcoran (2019) found that the presence of more passengers, in the absence of familiar strangers, was associated with more theft while the presence of more passengers had no impact of nuisance offences. Thus, we expect that the impact of familiar strangers on crime to vary by crime type.

In 2016, there were a total 22,596 nuisance offences recorded across Greater Brisbane. Of these, 36.43% ($n=8,231$) occurred within 400 m of a train station. Of the 46,505 recorded occurrences of theft in 2016 across Greater Brisbane, 12.47% ($n=5,802$) occurred within 400 m of a train station.

Independent Variables

Familiar Strangers Our key independent variable in this study is *familiar strangers*. Our measure of familiar strangers is computed using Translink smartcard data and is represented in the models as a percentage of the total passengers entering a given station on a given day. The percentage of familiar strangers is calculated for each Wednesday and Saturday (to represent weekdays and weekends respectively) over a consecutive six-month period between 15th July 2015 and 12th January 2016.

To enumerate the familiar stranger metric, we used a two-stage computational process. First, we constructed an encounter network to record encounters between pairs of transit riders. An encounter event is defined by a co-location instance between two transit riders entering/boarding the same station within a dynamic 30-min timeframe. Our operational definition of an encounter event extends previous definitions. First, we base the temporal search window on the train service schedule. The 30 min encounter window reflects train frequencies on the selected commuter line, where a train arrives every 12 min on peak hours and 30 min on off-peak hours (TransLink, 2020). This encounter window captures the temporal period when individuals entering the station are most likely to be waiting for the same service and have an opportunity to visually encounter each other. Second, the use of a dynamic window, in contrast to a static window, searches for instances of two or more individual passengers entering the same station within 30 min of each other across any time of the day. This is compared to static windows that segment the day into hourly blocks of time and search for shared boarding hour and station across individuals. The dynamic window was first proposed by Zhang et al. (under review)

Table 1 Summary statistics for all variables

	% or Mean (σ)	(min, max)
Nuisance presence	0.13 (0.33)	(0,1)
Theft presence	0.27 (0.08)	(0,1)
Familiar strangers count	106.27 (161.03)	(0, 841)
Total passengers	418.60 (475.57)	(1, 3582)
Risky facilities		
Bar	22.73 (41.93)	(0,100)
School	50.00 (50.02)	(0,100)
Park 'n' ride	81.82 (38.59)	(0,100)
Shopping centre	31.82 (46.60)	(0,100)
Neighbourhood characteristics		
Ethnic diversity	21.82 (10.04)	(8.41, 47.44)
Residential mobility	22.42 (9.87)	(3.70, 44.38)
Median Income	644.91 (175.38)	(411.7,0, 949.11)

and better reflects the fluidity of time in the real world and provides a more accurate measure of familiar strangers (i.e. individuals who visually encounter one another).

In the second stage of the computational process, the encounter network is utilised to identify pairs of transit riders who encounter one another *fortnightly or more frequently*, and these are classified into pairs of familiar strangers. We created a binary variable in the dataset to indicate trips involving a familiar stranger and enumerate the total number of daily familiar stranger trips at the station level. This value was used in the computation of percentage daily familiar strangers.

Station Environ We include variables in the model to indicate the presence of risky facilities in the station environ. Our selection of specific risky facilities to include in the analysis was guided by previous literature that highlights the association between bars, schools, shopping centres and car parks and risk of crime at transit stations (Adams et al., 2015; Loukaitou-Sideris et al., 2002; Newton & Bowers, 2007; Zahnow & Corcoran, 2019).

Neighbourhood Characteristics The influence of neighbourhood socio-demographic characteristics on active guardianship and crime is well documented (Reynald, 2009, 2010; Sampson et al., 1997; Wickes et al., 2017). In this study characteristics of the station neighbourhood were sourced from the Australian Bureau of Statistics (ABS) 2016 census data. The station neighbourhood is defined as the ABS 2016 Statistical Area Level 2 (SA2s) that the station falls completely within.[4] We include three measures to encapsulate neighbourhood disorganisation: median weekly income, ethnic diversity (computed as the mean of percent non-English-speaking households and percent residents born overseas), and percent of households living at a different

[4] All stations and there surrounding 400-m radial buffer fall within a single SA2.

address one year prior the census (Australian Bureau of Statistics, 2017). Summary statistics for all variables are presented in Table 1.

Analytic Approach

We estimate four multilevel logistic regression models to examine the influence of familiar strangers on the presence of nuisance offences and theft at train stations. We present an additional two multilevel logistic regression models that examine the moderating effects of neighbourhood socio-demographic characteristics on the association between familiar strangers and crime outcomes. We estimated the moderating effect of median income, % non-English speakers and residential mobility on the relationship between (a) familiar strangers and nuisance, (b) familiar strangers and theft on Wednesdays and Saturdays.[5] One of the interaction effects was significant, one was moderately significant and we present those results here. Models 1 and 2 examine the association between the daily percentage of familiar strangers and the presence of nuisance crime at stations on Wednesday (weekdays) and Saturday (weekends), respectively. Model 3 estimates the moderating effects of neighbourhood characteristics on familiar strangers and nuisance on Wednesdays. Regression results for models examining nuisance are presented in Table 2.

Models 4 and 5 estimate the relationship between daily percentage of familiar strangers and the presence of theft on Wednesday (weekday) and Saturday (weekend). Model 6 presents the moderating effect of neighbourhood characteristics on the association between familiar strangers and theft on Wednesday. Regression results for models examining theft are presented in Table 3.

All models are estimated in Stata 17.0 Collinearity diagnostics were computed. All individual VIF values were below 2.0 and the mean VIF was 1.55.

Results

Descriptive exploration of the data revealed significant differences in the average volume of familiar strangers emerging at stations on the indicated weekday (Wednesday) compared to the indicated weekend day (Saturday). On average, more familiar strangers emerge per day per station on weekdays ($\mu = 4{,}565$, 30.83% of the total daily passengers) than on weekend days ($\mu = 110$; 3.06% of the total daily passengers) (Fig. 1). Significant, temporary shifts in average daily volume of familiar strangers are also evident over time and co-occur with notable calendar events including a scheduled public holiday on a Wednesday in August and Christmas day in December. On Saturdays, the scheduling of local events associated with free public transport are associated with temporary reductions in familiar strangers and suggest that these events attract non-regular users to the public transit network.

[5] Moderating effects are estimating using interaction terms. Interaction terms are constructed within the Stata framework utilising the mean-centred variables.

Table 2 Logistic regression models estimating presence of nuisance offences at stations

	Model 1: Wednesday			Model 2: Saturday			Model 3: Interaction (Wednesday)		
	OR	*SE*	*P*	*OR*	*SE*	*p*	*OR*	*SE*	*p*
Familiar strangers (%)	0.994	0.018		1.029	0.064		0.885	0.370	
Risky facilities									
Bar	3.040	1.894	^	4.804	1.284	***	4.487	4.843	
School	0.539	0.218		1.012	0.198		0.392	0.525	
Park 'n' ride (carpark)	1.984	1.541		0.836	0.462		4.525	4.805	
Shopping centre	2.024	1.343		1.515	0.811		3.591	2.048	*
Neighbourhood characteristics									
Median income	0.996	0.002	^	0.996	0.001	**	0.888	0.533	
Ethnic diversity	0.981	0.032		0.955	0.022	*	0.395	0.166	*
Residential mobility	1.050	0.025	*	1.026	0.018		2.049	0.963	
Interactions									
Familiar strangers# median income							0.488	0.318	
Familiar strangers# ethnic diversity							1.567	0.415	^
Familiar strangers# residential mobility							0.712	0.478	
constant	0.271	0.440		1.066	0.838		0.015	0.017	
sigma_u	0.439	0.221		0.992	0.000		0.002	306.2	
fho	0.055	0.053		4.5e-07	0.000		7.5e-07	0.294	
Wald chi^2	30.93|***			80.83***			179.72***		
Log likelihood	-184.065			-179.85			-179.29		
AIC, BIC	388.13, 431.621			379.71,423.20			384.59,441.13		

$N = 26$ days, 22 stations (572 observations) $^p < 0.10$, $*p < 0.05$, $**p < 0.01$, $***p < 0.001$

Table 3 Logistic regression models estimating presence of theft at stations

	Model 5: Wednesday			Model 6: Saturday			Model 7: Interaction (Wednesday)		
	OR	*SE*	*P*	*OR*	*SE*	*p*	*OR*	*SE*	*p*
Familiar strangers (%)	0.995	0.016		0.973	0.074		1.085	0.294	
Risky facilities									
Bar	3.438	1.457	**	5.097	4.521	***	3.380	1.702	*
School	0.340	0.101	***	0.591	0.192		0.328	0.124	**
Park 'n' ride (carpark)	0.777	0.458		0.700	0.274		1.005	0.683	
Shopping centre	5.391	3.054	**	10.475	4.521	***	5.867	2.868	***
Neighbourhood characteristics									
Median income	0.998	0.001		0.999	0.001		0.754	0.324	
Ethnic diversity	0.945	0.026	*	0.895	0.021	***	1.619	0.221	***
Residential mobility	1.027	0.020		1.005	0.019		0.693	0.206	
Interactions									
Familiar strangers# median income							1.001	0.334	
Familiar strangers# ethnic diversity							1.619	0.220	***
Familiar strangers# residential mobility							0.693	0.206	
constant	0.357	0.388		0.488	0.353		0.033	0.024	
sigma_u	0.0008	0.000		0.001	0.000		0.0008	0.000	
rho	1.7e-07	0.000		3.03e-07	0.000		1.9e-07	0.000	
Wald chi^2	1.06.62***			139.65***			227.27***		
Log likelihood	-141.60			-137.08			-140.08		
AIC, BIC	303.19,346.68			294.15,337.64			306.15,362.69		

$N = 26$ days, 22 stations (572 observations) $^p < 0.10$, $*p < 0.05$, $**p < 0.01$, $***p < 0.001$

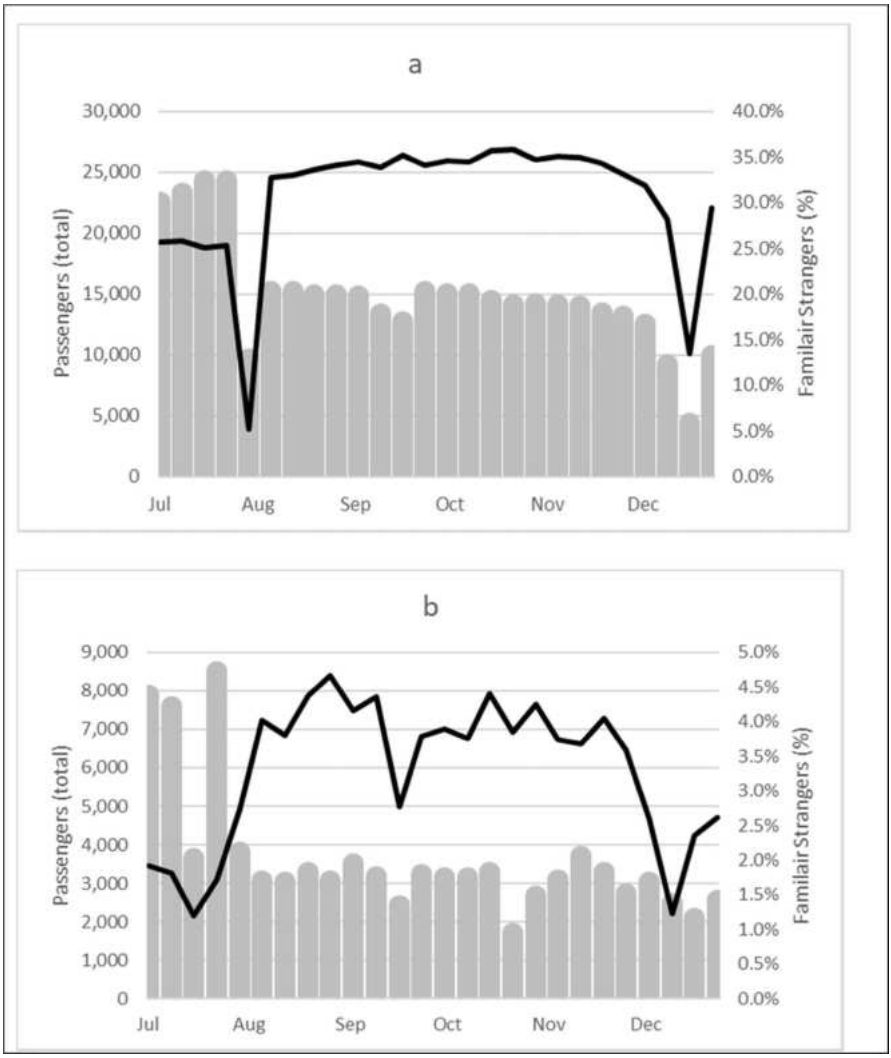

Fig. 1 Total passengers and % familiar strangers (July 2015-Jan 2016): Wednesday (**a**) and Saturday (**b**)

Logistic Regression Analysis

Nuisance Offences

Models 1 and 2 (Table 2) estimate the association between familiar strangers as a percentage of total daily commuters at stations and the presence of nuisance offences on Wednesdays and Saturdays. There is no evidence of a significant direct effect of familiar strangers on the likelihood of nuisance at stations on

either Wednesdays or Saturdays. Model 3 demonstrates that on Wednesdays the interaction effect of ethnic diversity and familiar strangers on nuisance is moderately significant (OR = 1.57, $p = 0.09$). We note this because it aligns with the highly significant findings of the later outlined theft model. The moderation effect shows that familiar strangers are negatively associated with the likelihood of nuisance at stations located in neighbourhoods with low ethnic diversity, but this association is not present in more diverse neighbourhoods. Again, we highlight that this association is only moderately significant ($p = 0.09$). There was no significant effects of median household income or residential mobility when estimating nuisance on Wednesdays.

On Wednesdays (Model 1), there is a positive and direct association between residential mobility and the presence of nuisance such that a one unit increase in recent population mobility increases the risk of nuisance by 5% (OR = 1.05, $p < 0.05$). On Saturdays (Model 2), the presence of a bar within the train station environ significantly increases the odds of a nuisance offence in station environs (OR = 4.80, $p < 0.001$) while neighbourhood median income (OR = 0.99, $p < 0.01$) and ethnic diversity (OR = 0.95, $p < 0.05$) are significantly and negatively associated with the odds of nuisance in the station environ There were no significant moderating effects of the neighbourhood characteristics when estimating Saturday models.

Theft

Models 4 and 5 (Table 3), estimate the association between familiar strangers as a percentage of total daily commuters at stations and the presence of theft on Wednesdays and Saturdays. There is no direct significant effect of familiar strangers on the likelihood of daily theft in station environs. On Wednesdays (Model 6), there is evidence of a significant moderating effect of ethnic diversity in the station neighbourhood on the association between familiar strangers and theft (OR = 1.62, $p < 0.001$). The moderation presented in Model 6 (Fig. 2) shows that familiar strangers are negatively associated with the likelihood of theft at stations located in neighbourhoods with low ethnic diversity, but this association is not present in more diverse neighbourhoods.

On Wednesdays (Model 4), train stations co-located with a bar (OR = 3.44, $p < 0.01$) or shopping centre (OR = 5.39, $p < 0.01$) are at higher risk of theft while those located nearby schools are less likely to experience theft on Wednesdays (OR = 0.34, $p < 0.001$). There is also a significant negative association between ethnic diversity and theft in station environs (OR = 0.95, $p < 0.05$). Results from the Saturday model (Model 5) estimating theft on Saturdays align with the results of the Wednesday model showing that train stations located within 400 m of a bar (OR = 5.10, $p < 0.001$) or shopping centre (OR = 10.48, $p < 0.001$) are more likely to experience theft. Neighbourhood ethnic diversity is significantly and negatively associated with the odds of theft at train stations suggesting that neighbourhood ethnic diversity may be a protective factor for theft.

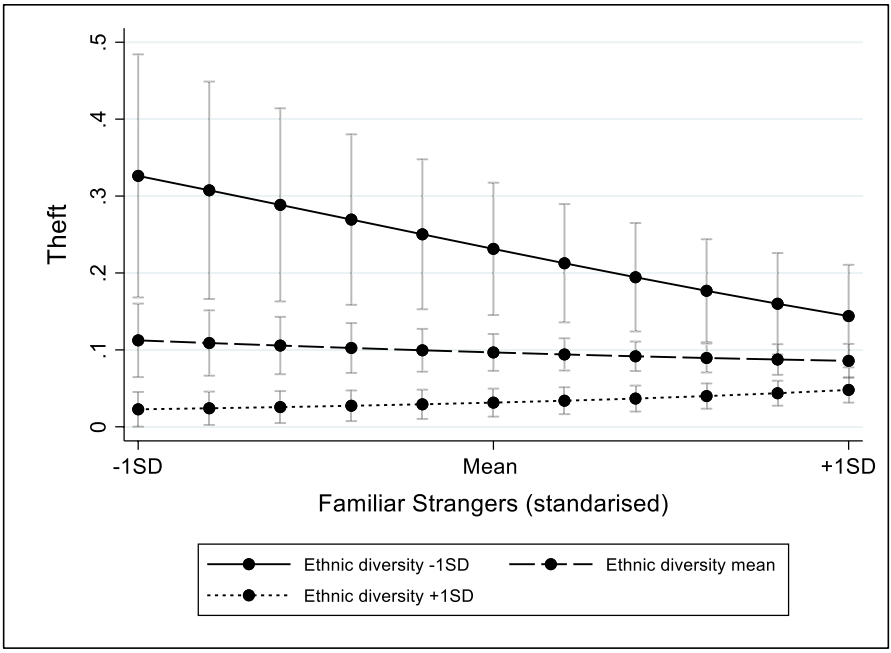

Fig. 2 Interaction: Familiar strangers# Neighbourhood ethnic diversity estimating theft at train stations

Discussion

Reliable, safe public transit networks are a core element of sustainable cities (Miller et al., 2016). While public transit networks are vital for managing urban issues of congestion and lowering automobile emissions, provision of services alone is not a panacea to urban ills. Rather, service provision must be coupled with resident motivation for mode shift away from private vehicle use to public transit ridership. Perceived crime and safety concerns are consistently reported as primary reasons for avoiding public transport (Kennedy, 2008; Taylor, 2002). A better understanding of factors that influence crime and feelings of safety at stations can inform transit planning and policy to improve ride share. In this study we used transit smartcard data to examine the impact of a unique urban phenomena, *familiar strangers* on the presence of theft and nuisance at train stations over a six-month period. Drawing on crime opportunities theories and Stanley Milgram's (1972) concept of the familiar stranger, we hypothesised that the likelihood of crime at train stations would be lower on days when the presence of familiar strangers was higher. Our results partially support this assertion. We discuss our key findings in greater detail below.

First, our study reveals distinct weekday, weekend differences in temporal patterns in familiar stranger volume over the course of a six-month time period. We were also able to elucidate the presence of temporary shifts in otherwise regular patterns of familiar strangers at stations associated with calendar events including public holidays, Christmas and New Year and demonstrate the potential impact of

initiatives such as free travel to events on diluting familiar strangers at stations. Further, our results provide support for the previous study by Zahnow et al (2020) that notes the influence of familiar strangers on crime varies across crime types.

While there was no evidence of a direct effect of familiar strangers on crime, there was evidence of a significant moderation effect indicating that familiar strangers may influence the likelihood of crime at stations under certain neighbourhood conditions. This aligns with Reynald's (Reynald, 2009, 2010) conceptualisation of guardianship-in-action that differentiates between four stages of guardianship intensity. According to this model familiarity with the environment and awareness of others supports capable supervision but alone is not enough to activate intervention for crime prevention. Social context – specifically social cohesion at places- is the final requirement for translating awareness into action (Reynald, 2009; Sampson et al., 1997). We found that the capacity for familiar strangers to influence crime at stations was moderated by neighbourhood characteristics associated with social cohesion, namely ethnic diversity.

Social disorganisation theory asserts that in wealthy, ethnically homogenous, residentially stable neighbourhoods' residents perceive a high level of social cohesion and shared values. This supports a willingness to intervene when problems such as crime arise in the neighbourhood because there is a belief that it is for the 'common good' (Shaw & McKay, 1942). When the neighbourhood is characterised by diversity, residents are hesitant to intervene because social cohesion is perceived as lower and shared values are less clear. Our results suggest that in Brisbane, familiar strangers have a beneficial impact on theft and a moderately beneficial impact on nuisance at stations located in ethnically homogeneous neighbourhoods but not those characterised by diversity. This finding aligns with the social disorganisation perspective and can be interpreted in three ways. First, it may suggest that high levels of ethnic diversity in some neighbourhoods obscure the development of familiarity among regular commuters around train stations. Psychological research reveals that strangers from one's own racial group appear more familiar than strangers from a different racial group (Zebrowitz et al., 2007). Thus, familiarity may be less intense and emerge more slowly in ethnically diverse settings. Alternatively, the finding may suggest that in ethnically diverse settings, the social cohesion and shared values required to generate a willingness among individuals to informally guard against crime is lacking among commuters. Thus, despite familiarity and the presence of familiar strangers in these settings, individuals lack a willingness to actively intervene to prevent crime. Finally, it is possible that the moderation effect is demonstrating that familiar strangers do not influence crime in ethnically diverse neighbourhoods because theft is already lower in these places. Our analyses demonstrate that the odds of theft and nuisance is lower at stations located in ethnic diverse neighbourhoods. Thus, it is possible that familiar strangers do not appear to influence crime around stations in ethnically diverse neighbourhoods because crime is already low there.

In addition to the socio-demographic characteristics at the neighbourhood level, the facilities co-located with train stations play an important role in crime risk. The results of our regression analyses provide support for crime opportunities theories by highlighting the influence of co-located risky facilities on train station crime. The

criminogenic effect of bars has received a great deal of scholarly attention. Our finding, that co-location with a bar increases the odds of theft and nuisance on weekdays and weekend days, echoes Bowers' (2014) assessment that bars can act as 'crime radiators' generating and dispersing crime into the immediate environment. On weekdays, proximate schools have a crime buffering effect for train stations, but this is not evident on weekend days. This reflects societal routines of work and education. When schools are operating through the working week, they generate *eyes on the street* (Jacobs, 1961) who act as legitimate guardians in the station environ which can deter offenders. On weekend days schools are largely vacant and do not provide this additional guardianship benefit to train stations nearby. Finally, our results show that shopping malls located nearby train stations increase the risk of theft at stations. This is likely because individuals accessing or departing the shopping mall make attractive targets for would-be offenders in the station environ as there is a high likelihood that they are carrying money or new purchases.

While our results, that the influence of familiar strangers on crime at stations is dependent on neighbourhood context aligns with our theoretical perspective and hypothesis, we did not find evidence of a direct impact of familiar strangers on crime. A possible explanation for this outcome is that the types of crime events we focused on in this study are too minor to elicit immediate action from other passengers (familiar strangers) (Fischer et al., 2006, 2011), or too limited in scope to identify the impact of familiar strangers. For example, nuisance offences tend to be directed at property as opposed to persons and therefore may not be affected by the familiar stranger relation which builds feelings of reciprocity between individuals. Further, previous studies show that theft offences tend to increase when total passenger presence is greater and offenders can use crowd density to protect their own anonymity (Newton, 2014; Zahnow et al., 2020). To successfully engage in crime guardianship familiar strangers would need to first notice and interpret incidents as crime events before assuming further action and intervention could occur (Reynald, 2009). Offences such as theft may not be observed when more passengers, familiar strangers or otherwise are present, therefore for this offence familiar strangers may have little capacity to hinder crime.

In this study we added to the literature on familiar strangers and knowledge on public transit crime. We also made an incremental, yet arguably important advance in the operational definition of the familiar strangers by fixing the encounter search window to a temporal period based on the train service schedule (30 min service intervals) and utilising a dynamic encounter window to identify potential encounters at stations. We argue this method of measure is more likely than previous operationalisations to identify instances of potential visual encounter. A notable limitation of this study is that we focussed on one weekday and one weekend day and we aggregated crime and familiar strangers to the day. While this was necessary to overcome computational challenges it may have limited our capacity to detect significant direct effects of familiar strangers on crime. Given our study only included one train line (22 stations) of seven comprising the Brisbane network an important area for future research is to up-scale this study to incorporate an entire transit network and to examine patterns of familiar strangers and crime across all days of the week. A final limitation associated with our study is that we defined train station environs

as the 400 m buffer radiating from the centroid of the station. We selected this area to align with the public health and criminology literature that uses 400 m to define a walkable area and notes that crime radiates 400 m from risky facilities including transit stations, respectively. However, we note that this area may be too large to truly detect the process of familiar strangers at the level of the train station. Following the operationalisation of familiar strangers demonstrated in this small-scale study, we suggest future research with a larger sample of stations is required to test for familiar stranger effects at various buffer distances (for example 100 m, 200 m).

Conclusion

Sustainable cities are underpinned by safe, reliable public transit networks.. However, crime at transit stations is a major impediment to achieving this goal. Here we examined the capacity for regular users of public transit stations to engage in active guardianship. Regular users of transit environs tend towards routinised visitation patterns, where there may be considerable capacity to activate informal guardianship through their familiarity with fellow passengers. This offers a low-cost, sustainable approach to station safety with the potential to enhance public transit ridership. This is especially important in a post covid environment where public transit patronage has been severely impacted. Further research is now required across a broader range of neighbourhoods to inform specific strategies best suited to different conditions and to better understand how individuals of various ages, gender, class and ethnicity come together at transit stations in different neighbourhoods to influence guardianship and crime potential.

Acknowledgements The authors would like to thank Queensland Department of Transport for providing access to the data required to complete this study.

Funding Open Access funding enabled and organized by CAUL and its Member Institutions. This research was supported by an Australian Research Council DECRA fellowship fund (DE200100359).

Data Availability Authors do not have permission to share the data.

Declarations

Competing Interest None to report.

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