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Mobilities and the flexible boundaries of the neighbourhood. A test with crime data in Barcelona

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ABSTRACT

This paper incorporates an explicit mobility dimension into the definition of the neighbourhood and explores its possible implications for the study of spatially distributed phenomena. We analysed the distribution of robbery and theft in Barcelona, Spain, as a testing application. Crime data were aggregated to nonoverlapping units (census tracts) and to a new measure of overlapping neighbourhoods, that we named 'walkhoods', accounting for the distance that can be covered in 5 min at a walking speed of 1 m/s, considering all possible physical barriers. The outcomes of regression models shed new light on the relationship between mobility and crime. When the walkhood scale is established, human mobility patterns have a stronger effect on the outcome variables than when census tracts are used. Results point to walkability constraints and social distances imposed by the massive presence of sporadic users in public spaces as strong predictors of crime occurrence, arguably due to their negative effects on neighbourhood social ties formation. Our findings suggest that more flexible definitions of the neighbourhood could address the social and spatial heterogeneity of urban spaces more properly than traditional approaches.

1. Introduction

Nonoverlapping administrative neighbourhoods have long been the predominant unit of analysis in social science research, mostly for reasons of pragmatism and data availability. Nonetheless, the perception of what constitutes a neighbourhood is hardly ascribable to official boundaries alone. Scholars have increasingly positioned in favour of exploring the implications of the porosity of these boundaries (Boruff, Nathan, & Nijënstein, 2012; Duncan et al., 2013; Forsyth, Van Riper, Larson, Wall, & Neumark-Sztainer, 2012; Johnston et al., 2000; Oliver, Schuurman, & Hall, 2007), which limits stretch or shrink according to people's daily activity locations, and the geographical movements around these locations. The present study follows this stream of research and uses *overlapping* clusters of streets based on the street network distance (or 'walkhoods') to study the distribution of robbery and theft in Barcelona during the three years before COVID-19 (2017, 2018, and 2019).

The idea of bespoke neighbourhoods is not new, and it aligns with a broader effort to estimate neighbourhood effects on social outcomes (Petrović, Manley, & van Ham, 2021). Our contribution, however, goes beyond the state-of-the-art in two ways. From a conceptual point of view, we combine two research traditions, that of the criminology of place (Weisburd, Groff, & Yang, 2012) and of the new mobility paradigm (Sheller & Urry, 2006), with poor explicit connections to date. From an empirical standpoint, we propose a technical refinement in the measurement of the urban pedestrian space. What we call walkhoods are layers of a flexible size defined as a function of walkability. Our walkhoods incorporate physical barriers (railroads, multi-lane avenues with central median, etc.) to account for reasons of possible variations in individual travel patterns and, therefore, they address one of the major limitations acknowledged in previous studies (Hipp & Boessen, 2013; Kim & Hipp, 2020). Statistical testing is based on generalized linear

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regressions and spatial error models. Crime data were aggregated at two different geographical units of analysis: census tracts, and walkhoods of flexible size based on a 5-min walking distance accounting for physical barriers. We found that the use of the walkhood approach depicts a significant relationship between human mobility patterns and crime distribution that is overlooked by models based on census tracts. These findings are robust to additional checks for spatial dependence.

The article is organized as follows: the following section briefly reviews previous studies that have focused on alternative operationalizations of the neighbourhood as an analytical unit; then, we introduce the conceptual grounds supporting our measure of walkhoods; a fourth section is devoted to present data and methods used for hypothesis testing, while the last two sections summarize the outputs of statistical modelling and the main conclusions of the study.

2. Administrative and bespoke neighbourhoods in criminological research

The interaction between the characteristics of a community and the personal and social conduct of its residents is one of the backbones of urban sociology and socio-environmental studies since pioneering studies by Park (1915), and Mckenzie (1921). After this initial impetus, consensus has grown about the influence of spatial contexts on individuals' outcomes, especially within the framework of neighbourhood effects research (Sampson, 2012; 2019 van Ham, Manley, Bailey, Simpson, & Maclennan, 2012). Scholars in criminology have significantly contributed to this debate. Studies that have tested the social disorganization hypothesis, for example, have shown that crime occurrence correlates with concentrated social disadvantages in the community in terms of greater inequality, social and family disruptions, and housing instability, among other factors (Bursik, 1988; Cantillon, Davidson, & Schweitzer, 2003; Morenoff & Sampson, 1997; Wilcox, Cullen, & Feldmeyer, 2018). Analyses inspired by the routine activity and crime pattern theories suggest that variations in crime rates depend on the interconnection between social behaviours (of victims, offenders, and guardians) and the characteristics of the built environment (land use, activity nodes, and street layout) (Brantingham & Brantingham, 1993; Cohen & Felson, 1979; Felson & Eckert, 2018; Johnson & Summers, 2015; Menting, Lammers, Ruiter, & Bernasco, 2020; Ruiter, 2017). Contributions from the criminology of place point to the strong spatial concentration of crime within a small portion of street segments of a city (Braga, Andresen, & Lawton, 2017; Curman, Andresen, & Brantingham, 2015; Weisburd, 2015; Weisburd, Shawn, Cynthia, & Sue-Ming, 2004; Weisburd et al., 2012).

Overall, the studies reported above all emphasize a connection between space and crime. The question remains, however, that the influence of the context on social outcomes is a function of how the neighbourhood is defined. Most of the existing research is based on *a priori* definitions of the neighbourhood, in which boundaries are defined for administrative purposes (Rey et al., 2011). Preference for administrative units is often a choice of convenience as they are ready-to-use and relief researchers to compute *ad hoc* geographies. Yet, a major flaw of this predominant pragmatism is that it has driven away any attempt to develop theoretical considerations on how to properly measure socio-spatial contexts (Petrović et al., 2019). This issue is not trivial due to statistical biases derived from the modifiable areal unit problem, or MAUP (Openshaw & Taylor, 1979), cautioning against the scale and zonal effects, and the probability of getting radically different results at different levels of geographical aggregation. To address this concern, scholars have progressively integrated alternative approaches to defining the boundaries of bespoke neighbourhoods based on GPS walking data (Boruff et al., 2012), buffering techniques (Duncan et al., 2013; Forsyth et al., 2012; Oliver et al., 2007), clustering and spatial contiguity techniques (Johnston et al., 2000; Lee, Farrell, Reardon, & Matthews, 2019; Martí-Ciriquián, Serrano-Estrada, Nolasco-Cirugeda, & López-Baeza, 2021; Thomas, Harris, & Drawve, 2022), or the spatial extent of social ties (Hipp, Faris, & Boessen, 2012).

3. A re-orientation towards a mobility-based catchment area: the *walkhoods*

Despite current advances, the idea of a cluster of nonoverlapping neighbourhoods and the GIS-based buffers of a constant size fail, in our view, to fully incorporate an explicit mobility dimension and its possible implications for the study of spatially distributed phenomena. Contemporary cities are exposed to an unprecedented growth of people, goods, and immaterial mobilities of such magnitude that are reshaping the very ontology of places (Cresswell, 2011; Kesselring, 2006; Sheller & Urry, 2006; Verstraete & Cresswell, 2002). This is also true for the case study under scrutiny here. The city of Barcelona is one of the most important tourist hubs in the Mediterranean, with almost twenty million overnight stays the year before COVID-19. In parallel, the Catalan capital is crossed by a significant number of floating populations that move across its territory both daily (e.g., commuters within the metropolitan area) and over the mid- and long-terms due to transnational mobilities and gentrification processes (Cocola-Gant & López-Gay, 2020). Human mobility flows have major implications in that the spatial boundaries of a neighbourhood are nothing less than functional configurations that people constantly shrink and stretch depending on the extent of their activity space. It follows that neighbourhood geographies cannot be fully understood without considering their socio-geographical fuzziness and the broader spatial context within which they are located.

The relationship between urban mobilities and crime patterns has been previously addressed by scholars in criminology whose conclusions point to a positive correlation between the so-called 'ambient population' (i.e., the number of people present in outdoor areas at a given point in time) and the incidence of crime (Browning, Pinchak, & Calder, 2021; De Nadai, Xu, Letouzé, González, & Lepri, 2020; Lee, Haleem, Ellison, & Bannister, 2021). Along the same lines, previous studies highlight a positive relationship between walkability and crime, which is ascribed to the interaction with land-use diversity and a greater opportunity to commit a crime in places where people hang around (Cowen, Louderback, & Roy, 2019; Foster et al., 2014). Yet, this association was also found to be significantly moderated by the socio-environmental features of the neighbourhood (Lee, 2021; Lee & Contreras, 2021), and sensitive to time variations (Kim & Wo, 2023).

Nevertheless, no study at the time of this writing has looked at how human mobilities *land* in overlapping socio-ecological systems and what are their repercussions on crime occurrence. Taking the specificities of Barcelona into account, we explored the link between mobility and crime at micro-scales by testing the effect of spatial occupancy patterns, extracted from mobile-phone data, within a general model on robbery and theft victimization. We did so by using what we call 'walkhoods' as the unit of analysis. The definition of walkhoods is sourced from two previous measures of bespoke neighbourhoods: the egohoods and the pedestrian sheds. The concept of egohood has been proposed by Hipp and Boessen (2013) as a possible alternative to ecological models of crime. Geographically speaking, egohoods are circular buffers of a constant size based on straight-line Euclidean distances from the centroids of each block of the city. Block-based egohoods have later evolved into street egohoods, i.e. street network buffers rather than circular buffers (Kim & Hipp, 2020). As for the pedestrian sheds, they have been used by urban planners to define a walkable catchment area within a distance that can be covered through a 5-min walk. The 5-min cut-off is generally considered the distance that people are willing to walk before opting to drive or use motorized public transportation (Atash, 1994). For their very nature, however, pedestrian sheds have mostly been used for planning purposes and less so in empirical research. From a technical point of view, their geometric centre is located around local community assets (schools, parks, etc.) to estimate their accessibility by foot.

Our walkhoods offer an alternative to overcome some of the limitations both of egohoods and pedestrian sheds. Compared to (street) egohoods, the walkhoods measure the actual distance that can be traversed within 5 min accounting for *all* possible physical barriers. The simulated walking speed is 1 m/s based on a rough estimate of the average walking speed retrieved from the comparative analysis of the 'pace of life' by Levine and Norenzayan (1999). The size of a walkhood, and allegedly the possibility for social interactions herein, is smaller when pedestrians encounter morphological constraints, including streets with a pronounced slope. Compared to pedestrian sheds, which are set around specific focal points (e.g., a school, a park, a community centre, etc.), our walkhoods are set around *all* street segment centroids of the city. This allows walkable catchment areas to simulate the symbolic overlapping of individuals' cognitive appraisal of their lived neighbourhood. As a result, the walkhoods provide a direct estimation of a walkable area as opposed to previous measures such as the 'walk score', for example, which have defined walkability as a proxy for street connectivity, residential density, and accessibility to public transit (Carr, Dunsiger, & Marcus, 2010; Cowen et al., 2019; Lee, 2021; Kim & Wo, 2023; Lee & Contreras, 2021).

4. Data and method

4.1. Crime data

Robbery and theft are classified by the local penal code as property crimes, although the former involves the use of violence or the threat of it against a victim, which is absent in the latter. We accessed the geographical coordinates (latitude and longitude) of these two crimes, which allowed us to count them within the two units of analysis (census tracts and walkhoods). We computed averaged values for both over three years (2017, 2018, and 2019) to reduce possible biases due to yearly fluctuations, therefore aligning with the analytical strategy used by Hipp and Boessen (2013) to test the suitability of the egohood approach for crime analysis. An average of 10,693 robberies ($\sigma = 1730$) and 44,545 thefts ($\sigma = 4540$) per year were reported to, or recorded by, the local police in Barcelona during the time frame considered.

4.2. Correlates

Statistical modelling entailed three sets of predictors respectively related to the characteristics of the social environment, the spatial patterns of human mobility, and the use of land. As for the first set of variables, our focus was on: the log-transformed household net income after taxes and transfers; the 80/20 ratio as a proxy for income inequality measured as the proportion of incomes received by the population within the top quintile in relation to those received by the population within the bottom quintile; and the residential population density (per hectare). All these variables were available for 2019 at the level of census tracts as part of the Household Income Distribution Atlas elaborated by the Spanish National Institute of Statistics (INE, 2021a; INE, 2021b). The natural log of the population was also included as an offset variable in generalized linear models (Cameron & Trivedi, 1998), with a coefficient constrained to 1.

Measures of human mobility patterns were extracted from a dataset provided by Vodafone and accessed through the Municipal Data Office of the Barcelona City Council in the framework of a collaboration in the [*anonymized for peer review*] project funded under the European Union's Horizon 2020scheme. Vodafone holds 23 per cent of the mobile phone market share in Spain. The technical specifications accompanying the raw dataset clarify that the data owner uses an algorithm (not disclosed to the authors of this paper) to estimate the total number of passers-by at a given location, including customers of other mobile phone operators in Barcelona. We have therefore no reason to expect a selection bias in our measures.

We were able to access a sample of Vodafone's mobile phone data covering the period between April and December 2019. The dataset encompasses information on the total volume of passers-by crossing the city of Barcelona on foot or by motorized transport at a geographical resolution of 500 m-square grids. The dataset differentiates between local passers-by and international visitors whose mobile phones are roaming, and within each of these two categories, public space users are further labelled as 'sporadic' versus 'frequent'. We calculated the percentage of sporadic international visitors in each square grid based on the assumption that the share of public space users who are unfamiliar with the social and physical environment they are visiting might undermine the ability to mobilize informal mechanisms of social control. Vodafone's data also include a breakdown by age range, which was used to extract the percentage of passers-by aged 18–34, in line with the results of previous studies showing that the frequency of offending usually peaks in the youngest cohorts.

We controlled our results for the number of bars, restaurants and hotels; the number of cultural and recreational facilities; and the size of the geographical unit of analysis. The source of information to compute the first two variables is the 2019 municipal register on commercial activities located on the ground floor with the respective geographical coordinates. The size of the area was calculated on our own based on the spatial properties of the polygons representing the census tracts and walkhoods, respectively. In the case of walkhoods, the size of the area is *de facto* directly proportional to the walkability of the surroundings. All correlates, except for the log net household income, have been standardized (z-scores) before running the models. A description of the variables, before standardization, is presented in Table 1.

4.3. Geographical scales of analysis and data apportionment

Crime data and correlates were aggregated at two different geographies to compare the performance of the statistical models using nonoverlapping as opposed to overlapping scales of analysis. Nonoverlapping scales refer to census tracts as a proxy for administrative neighbourhoods. Census tracts are the smallest geographical units for which statistical data is collected and processed by the Barcelona City Council. Their delimitation corresponds to the need to provide a homogenous subdivision of the population for census and electoral purposes, with approximately 1000 residents per tract. As for overlapping scales, we constructed layers of flexible sizes as a function of walkability and physical barriers. We first identified the geometric centre (or centroid) of each one of the 14,328 street segments in Barcelona (see Fig. 1). Then, using data retrieved from HERE Maps APIs, we calculated the size of an area of influence based on the distance that a pedestrian could cover on foot moving from the centroid to all directions at a walking speed of 1 m/s. The HERE platform combines highly detailed roadway and road conditions data with the information provided by its users. Therefore, the reliability of the walkhood calculation is determined by an empirical value and not only by a theoretical approximation. As an innovation to previous measures of bespoke neighbourhoods,

Table 1
Data description (before standardization).

	Census tracts			Walkhood		
	N	Mean	SD	N	Mean	SD
Robbery	1043	10.1	20.6	14,328	45.6	68.7
Theft	1043	42.1	164.4	14,328	199.8	452.3
Family income (log)	1043	10.5	0.3	14,328	4.5	0.1
Income inequality	1043	2.8	0.4	14,328	2.9	0.4
Population density (per ha)	1043	420.1	216.2	14,328	331.1	163.6
Sporadic international, %	1043	17.2	10.1	14,328	18.1	11.1
Younger cohorts (18–34)	1043	31.1	2.1	14,328	31.3	2.1
Bar, restaurants, and hotels	1043	10.5	11.8	14,328	91.2	97.5
Cultural and recreational facilities	1043	0.9	1.7	14,328	4.1	5.3
Size of the area (ha)	1043	9.6	0.5	14,328	16.7	0.1
Population	1043	1503	340	14,328	5812	3007

our own considers all possible physical barriers that the pedestrian encounters while walking (railroads, multi-lane avenues with central median, road slope, etc.). We drew concave hulls (k-nearest neighbour) to generate polygons containing the walkhoods and to aggregate point data. Fig. 2 gives an example of two overlapping walkhoods in the city centre of Barcelona.

Given the lack of socio-demographic data at the level of street segments, census data were imputed by computing their weighted average values and apportioning them to the geography of walkhood, thus replicating an approach previously implemented by Kim and Wo (2021). Using the intersect command from the *fTools* plugin in QGIS 3.10, we calculated the intersection of the census tract polygons with the concave hulls delimiting our walkhoods. The ratio of the intersected area to the area of the original polygon was then used to determine a weighted value for each measure of walkhood. The same procedure was followed to impute Vodafone square-grid data.

4.4. Modelling strategy

A two-step modelling strategy was followed. First, considering the over-dispersion in our outcome variables, we run negative binomial generalized linear models. Missing values were dropped from the analysis (listwise deletion). At a later stage, we used residuals for model diagnostics to evaluate the model assumptions of linearity, equal variance, and normality. Residual maps are presented in Fig. 3a-d. Based on the results of Moran's I statistic indicating positive spatial autocorrelation, we considered fitting spatial error models with queen contiguity-based spatial weights in which the outcome variable was the logged crime rate. Non-spatial and spatial modelling were estimated using the *MASS* and *spdep* packages in R.

5. Results

5.1. Negative binomial models

Outputs of negative binominal generalized linear models show a significant improvement in fit relative to the null, according to the likelihood ratio chi-square test. Multicollinearity diagnostics did not detect values of the variance inflation factor (VIF) above desirable cut-offs (Montgomery, Peck, & Vining, 2001). Regression coefficients are reported in Table 2, separately for robbery and theft counts.

Robbery and theft in Barcelona correlate with lower family incomes and greater income inequality, which suggests that these two property crimes are more prevalent in urban areas where material deprivation is accompanied by a certain degree of economic polarization. The presence of young people (aged 18–34) in public spaces emerges as a consistent predictor of both crimes, together with the spatial concentration of bars, restaurants and hotels, and to a lesser extent of cultural and recreational facilities. The association between robbery, theft and the spatial concentration of commercial activities could also explain the negative sign of the residential population density in our models (i.e., crime is concentrated in non-residential areas). Results of negative binomial models point to divergent interpretations regarding the role of sporadic international visitors. The model depicts a significant positive

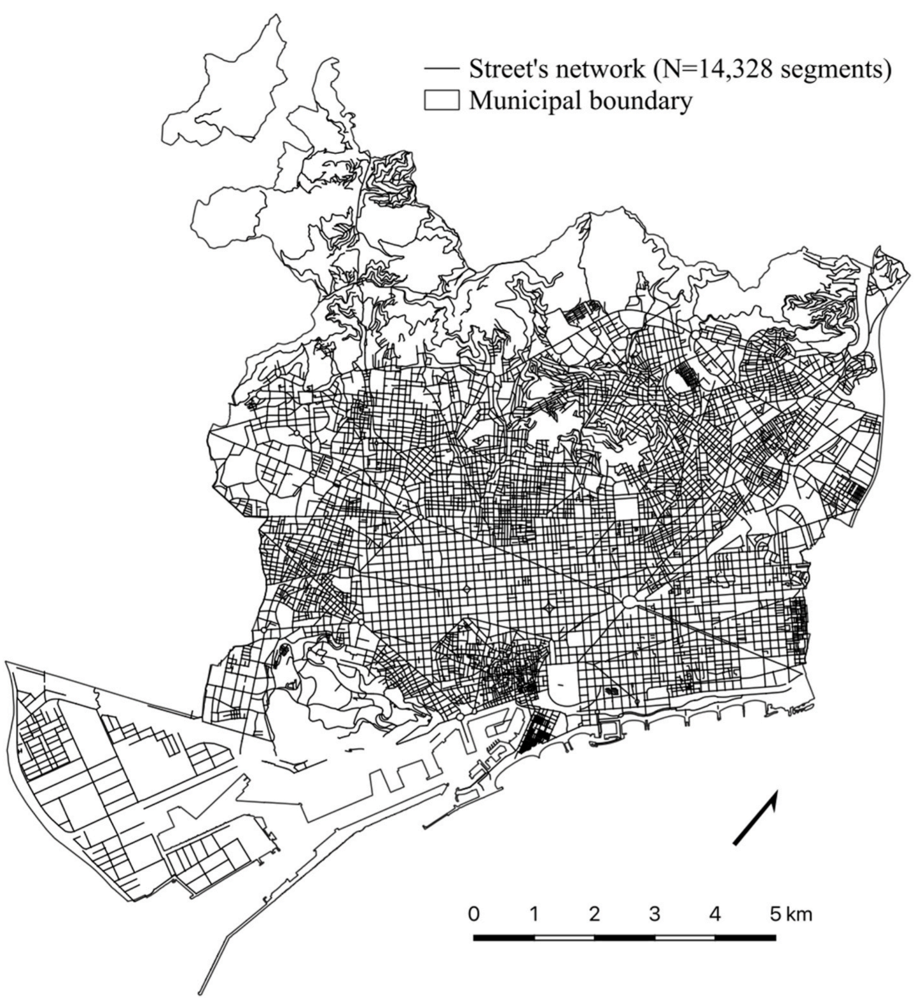

Fig. 1. Street network within the municipal boundaries of the city of Barcelona.

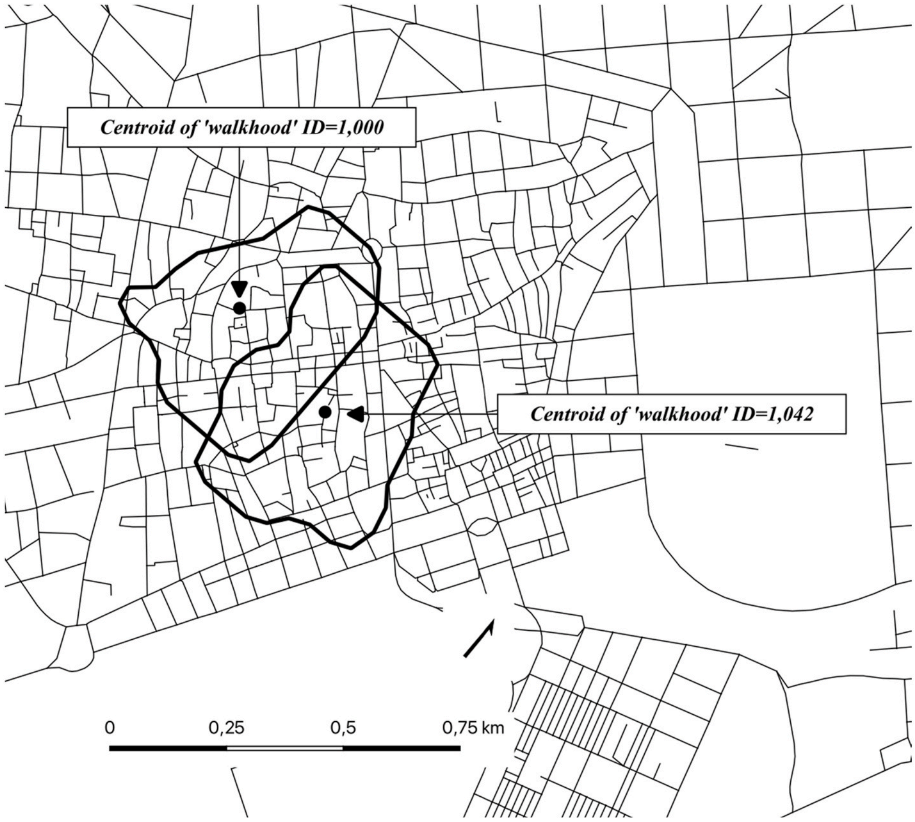

Fig. 2. Visualization of two overlapping walkhoods in the Gothic Quarter.

correlation with theft, whereas the percentage of sporadic passers-by from abroad significantly correlates with robbery only when the walkhood scale is established.

Overall, a comparison of the effect of covariates suggests that socio-environmental measures (i.e., income, inequality, and density), and spatial patterns of visitors' mobility have a stronger effect on the outcome variables when using walkhoods than when data are aggregated to census tracts. Likewise, the size of the area plays a controversial role depending on the geographical scale of the analysis. Models at the census tract level show that larger sizes increase the probability of a robbery or a theft occurring, which makes sense as these two types of crime predominantly take place in outdoor spaces. However, the sign of this relationship goes in the opposite direction in models based on walkhoods, thus opening an alternative interpretation according to which lower levels of pedestrian accessibility would lead to more crime. Considering that one of the criteria in the construction of our flexible neighbourhoods is walkability, this stands as a suggestive result. We conjectured that the combined effect of a reduced walkable space with a high concentration of public space users who are not familiar with the socio-environmental surroundings (i.e., sporadic international visitors) could be a reason for social withdrawal and eventually an increased risk of victimization. Johnson-Neyman intervals support this hypothesis, which indeed would require further testing, showing that when the size of the area shrinks, the proportional effect of the presence of sporadic internationals on crime significantly increases.

Looking at the model performance, values of McFadden's pseudo-R^2 are 0.17 and 0.18, respectively for robbery and theft models at the census tract level, compared to .13 and .12 when correlates are aggregated at the walkhood level. The normal probability plots of the standardized deviance residuals support the condition that the error terms are normally distributed, yet with a slightly skewed distribution and individual points outside of the 95 % confidence bands of the quantiles. We looked closer at the possible undue influence of these outliers over regression coefficients and computed Cook's distances without disclosing values greater than 1, which may have been cause for concern (Cook & Weisberg, 1982; Stevens, 2002). Also, robustness checks after outlier removal (i.e., standardized deviance residuals with absolute values greater than 3), which are available upon request, did not reveal significant changes in regression coefficients.

5.2. Spatial error models

We checked for spatial dependence in the error terms of the generalized linear model. Comparing the results reported in Table 3 to the generalized linear regression models in Table 2, the spatial error model is revealed to be better fitter to data since AIC values are smaller in the spatial error model than those in the negative binomial model.

Fitting spatial error models in part reduces discrepancies related to the effect of covariates. In general, changes are just minor adjustments in coefficient values, and they corroborate that the walkhood scale emphasizes a significant relationship between mobility and crime in Barcelona that is less evident (or even counterintuitive) when models are fitted with census tracts. Walkhood-based estimates point to a combined influence of the presence of sporadic international visitors and a reduced pedestrian space on robbery and theft occurrence in the Catalan capital.

6. Conclusions

Crime modelling is very sensitive to the geographical scale of analysis (Weisburd et al., 2012), and yet most of the research in this field relied upon pre-packed administrative neighbourhoods as a pragmatic choice for modelling, mostly due to data accessibility. In the review of the literature, we saw that there has been a growing interest over the last few decades in proposing alternative measures of the neighbourhood that could match more closely to resident perceptions and their activity space (Boruff et al., 2012; Johnston et al., 2000; Lee et al., 2019;

Fig. 3. Residual maps showing the spatial patterning of areas of over-prediction (negative residuals, or dark tones) and under-prediction (positive residuals, or light tones).

Martí-Ciriquián et al., 2021). Building on these sets of literature, we proposed the walkhoods as a new analytical unit to estimate the risk of robbery and theft in the city of Barcelona. From a strictly geographical point of view, the main difference between a walkhood and a traditional administrative unit, such as census tracts, is that the former overlaps with its neighbours, whereas the latter doesn't. Our contribution was to elaborate a fine-tuned measure of a flexible catchment area to incorporate physical barriers (railroads, multi-lane avenues with central median, etc.) and account for reasons of possible variations in individual travel patterns. To this end, we used the centroids of street segments (as in Kim & Hipp, 2020) to compute an activity space within a given walking distance (5 min on foot) and walking speed (1 m/s). Beyond

Table 2
Negative binomial models.

	DV = robbery (2017–2019)			DV = theft (2017–2019)		
	Census tracts	Walkhoods	Ratio[a]	Census tracts	Walkhoods	Ratio[a]
Social environment						
Family income (ln)	−.09*** [−.14, −.04]	−.10*** [−.12, −.09]	1.11	−.16*** [−.22, −.11]	−.23*** [−.25, −.21]	1.43
Income inequality	.09*** [.03, .14]	.13*** [.12, .15]	1.44	.13*** [.07, .19]	.13*** [.11, .15]	1.00
Residential population density	−.37*** [−.42, −.32]	−.45*** [−.46, −.44]	1.21	−.44*** [−.49, −.39]	−.60*** [−.62, −.59]	1.36
Human mobility patterns						
Sporadic international, %	−.04 [−.11, .03]	.10*** [.08, .12]	OPP	.22*** [.15, .30]	.59*** [.57, .62]	2.68
Younger cohorts (18–34)	.38*** [.32, .45]	.44*** [.42, .46]	1.15	.33*** [.26, .40]	.28*** [.26, .30]	.84
Land use and street layout						
Bar, restaurants, and hotels	.29*** [.24, .35]	.21*** [.19, .22]	.72	.41*** [.35, .48]	.36*** [.34, .39]	.87
Cultural facilities	.09*** [.04, .13]	.10*** [.08, .12]	1.11	.09*** [.04, .14]	.00 [−.01, .02]	.01
Size of the area	.06*** [.02, .11]	−.03*** [−.04, −.02]	OPP	.08*** [.03, .14]	−.05*** [−.06, −.04]	OPP
N	1046	13,871		1054	13,871	
Deviance/df	.97	1.06		1.03	1.09	
AIC	5865.2	114,134		7850.1	145,963	
McFadden's pseudo-R^2	.17	.13		.18	.12	
Dispersion parameter (θ)	3.15	3.23		2.03	1.97	

***($p \leq .001$), **($p \leq .01$) and *($p \leq .05$).
OPP = opposite direction.
[a] Ratio of 5-min walkhood parameter estimates to census tract estimates.

Table 3
Spatial error models, std. Errors in parenthesis.

	Robbery rate (log)		Theft rate (log)	
	Census tracts	Walkhoods	Census tracts	Walkhoods
Social environment				
Family income (ln)	−.04 (.03)	.00 (.01)	−.06 (.03)	−.02 (.01)
Income inequality	.04 (.02)	.07*** (.01)	.08** (.03)	.12*** (.01)
Residential population density	−.42*** (.02)	−.36*** (.01)	−.44*** (.02)	−.46*** (.01)
Human mobility patterns				
Sporadic international, %	−.01 (.05)	.06** (.02)	.20*** (.05)	.23*** (.03)
Younger cohorts (18–34)	.28*** (.05)	−.00 (.01)	.25*** (.05)	.00 (.02)
Land use and street layout				
Bar, restaurants, and hotels	.21*** (.02)	.10*** (.01)	.35*** (.03)	.20*** (.01)
Cultural facilities	.07*** (.02)	.05*** (.01)	.12*** (.02)	.01* (.00)
Size of the area	.14*** (.03)	−.01*** (.00)	.15*** (.04)	−.01*** (.00)
N	1055	13,775	1055	13,775
AIC	2201.1	26,226	2411.4	30,888

***($p \leq .001$), **($p \leq .01$) and ($p \leq .05$).

technical differences, the definition of walkhoods entails a key conceptual novelty as well. In fact, if census tracts are designed to maximize social and spatial homogeneity (with a look towards administrative and city management purposes), and constant-sized egohoods proposed by Hipp and Boessen (2013) were thought to maximize social heterogeneity (but failed to address spatial heterogeneity), only the walkhoods address both social and spatial heterogeneity.

Our tests show that census tracts have slightly better predictive ability than walkhoods in terms of McFadden's pseudo-R^2, and more generally, the assessment of model performance across different geographies offers mixed evidence that overlapping units of analysis should be preferred over nonoverlapping ones. The use of walkhoods was a burden computationally, with our models converging only after a significant amount of time. Also, the huge intersection between polygons affects the models' performance due to spatial dependence of imputed value (Ottensmann, 2014). We have tried to address this issue through the implementation of resampling procedures and spatial error models with queen contiguity spatial weight matrices.

However, beyond a purely technical point of view, the walkhood approach reveals that smaller areas (i.e., less accessible for pedestrians) crossed by sporadic visitors tend to concentrate more crimes. This correlation between mobility patterns and crime, which is strongly supported by previous literature (Browning et al., 2021; De Nadai et al., 2020; Lee et al., 2021), is largely overlooked by models based on census tracts. Despite the need for further testing, this finding is quite evocative considering that one of the criteria in the construction of our walkhoods was walkability and how far can one go within a certain walking distance. Interaction effects support a preliminary hypothesis that the size of the pedestrian space interacts with the spatial concentration of international visitors in public space, which undermines neighbourhood social links, reduces informal social control, and eventually increases the risk of victimization. A comparison of the effect of correlates also points to a few findings that are less sensitive to the geographical scale used. For instance, concentrated disadvantage in the community (i.e., low income and diffuse inequality) significantly correlates with robbery and theft spatial distribution in Barcelona, which is consistent with the social disorganization hypothesis (Bursik, 1988; Cantillon et al., 2003; Sampson & Groves, 1989; Sun, Triplett, & Gainey, 2004). At the same time, robbery and theft tend to be located close to bars, restaurants, hotels, and cultural and recreational facilities. These results align with routine activity and crime pattern theories (Brantingham & Brantingham, 1993; Cohen & Felson, 1979; Felson & Eckert, 2018), and can inform future risk terrain modelling (RTM) approaches oriented to substantiate risk-based policing (Caplan & Kennedy, 2016).

This study is affected by some well-known limitations attached to crime data in terms of underreporting and dark figures. Another area of potential limitation is related to the lack of data at finer geographies, which we have tried to address by means of a data imputation procedure that has shown its effectiveness in previous studies (Kim & Wo, 2021). However, street-level or point data would have been preferable. Further limitations depend on the cross-sectional nature of the analysis, its focus on one single city and the fact that we have used only one phone provider. Future research is also welcomed to rectify some of the technical flaws in our operationalization of walkhoods, for instance, integrating new criteria into their construction, such as the spatial extent of social ties, which necessarily stretch beyond the boundaries of the administrative neighbourhood. As for our study, despite the lack of conclusive arguments, it is key in our view to keep exploring unconventional definitions of spatial contexts to fully disclose the impact of local and transnational mobility practices on our cities. In line with the conclusions of Spielman and Yoo (2009), scholars are increasingly aware that "if the spatial dimension of the independent variable(s) does not match the areal extent of the environmental influences on the outcome regression results are inaccurate" (p. 1104). In this paper, we showed how mobility flows in urban hubs like Barcelona emerge as a significant factor in reshaping the geographical contours of people's lived neighbourhoods and how this may impact crime levels. It is our strong belief that our modelling approach can function as a starting point to test the implications of socio-spatial reconfiguration in urban settings in countless of other domains such as efficient planning and delivery of services, fiscal equalization, retail analysis, transport demand, and emergency preparedness.

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CRediT authorship contribution statement

Riccardo Valente: Writing – original draft, Formal analysis, Data curation, Conceptualization. **Juan José Medina-Ariza:** Writing – review & editing, Funding acquisition, Formal analysis. **Juan Carlos Pérez-Pintor:** Writing – review & editing, Data curation. **José Antonio Gutiérrez-Gallego:** Writing – review & editing, Data curation.

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