
AN ANALYSIS OF STREET ROBBERY AND RESIDENTIAL BURGLARY THROUGH INTEGRATION OF AXIAL LINES, SEGMENTS CONNECTIVITY AND GIS

025

Antônio Tarcísio Reis

School of Architecture, Federal University of Rio Grande do Sul

Luiza Vedana

School of Architecture, Federal University of Rio Grande do Sul

Celina Dittmar

School of Architecture, Federal University of Rio Grande do Sul

Keywords:

Street robbery
Residential burglary
Integration
Axial lines
Segment connectivity and GIS

Antônio Tarcísio R

*School of Architecture–
PROPUR-Federal University of
Rio Grande do Sul,
Praça Carlos Simão Arnt 21,
apto.202, Bela Vista, Porto
Alegre, RS, Brazil
tarcisio@orion.ufrgs.br*

Luiza Vedana

*School of Architecture–
PROPUR-Federal University of
Rio Grande do Sul,
Praça Carlos Simão Arnt 21,
apto.202, Bela Vista, Porto
Alegre, RS, Brazil
tarcisio@orion.ufrgs.br*

Luiza Vedana

*School of Architecture–
PROPUR-Federal University of
Rio Grande do Sul,
Praça Carlos Simão Arnt 21,
apto.202, Bela Vista, Porto
Alegre, RS, Brazil
celina.dittmar@gmail.com*

Abstract

This paper examines the relationship between configurational properties, such as axial lines integration levels and segments connectivity values, and different types of crimes, such as street robbery and residential burglary, in two Porto Alegre typically residential boroughs. Apart from the socio-economic causes of urban insecurity, many studies have shown that physical variables may play a role in increasing or decreasing opportunities for crime in distinct cities. Nonetheless, there is a need to better understand the relationship between configurational properties, such as axial lines integration levels and segment connectivity values, and different types of crimes, specifically, in the context of residential boroughs in cities in southern Brazil. Although many authors have dealt with the subject of security in Brazilian cities, the relationship between security and urban form and configuration has not been dealt with directly. Data related to the occurrence of street robbery and residential burglary was collected for Menino Deus borough, in the Department of Public Security of Rio Grande do Sul State, for a period of ten months. This data was computed in ArcGIS, as a way of generating maps according to the different types of crimes, and allowing the visualization of spatial patterns of such crimes. Analysis of axial lines integration levels and segment connectivity values was carried out in Depthmap considering the axial map of the two boroughs. The findings show, for example, that increase in either residential or non-residential units in a segment decrease residential burglary having the ratio of residential to non-residential uses in favour of residential units. A better understanding of the complex relationship between street robbery and residential burglary and configurational attributes of residential urban areas can be derived from these initial results. This understanding may allow in the future, the consideration of urban configuration as playing a role in urban security. Moreover, is less difficult and expensive to prevent crime through measures carried out in the design of residential areas than to implement changes latter on, after these areas have been built. A work to be done next is the consideration of constitutedness, time of the day, apart from crime as identified by the residents and their perceptions about security in these residential boroughs.

Introduction

Apart from the socio-economic causes of urban insecurity, many studies have shown that physical variables may play a role in increasing or decreasing opportunities for crime in distinct cities

(Jacobs 1961; Newman 1972; Hillier & Shu 1999; Voordt & Wegen 1990; Poyner 1983; Reis et al 2003; Shu & Huang 2003). Nonetheless, the effects of such physical, design or spatial variables on crime appear to be complex and yet not well established in the literature. As highlighted by Hillier & Sahbaz (2005, p.451), in their paper entitled 'High Resolution Analysis of Crime Patterns in Urban Street Networks: an initial statistical sketch from an ongoing study of a London borough', 'An increasingly animated debate is taking place between two schools of thought [New Urbanism and Newman's Defensible Space, 1972] on how to design cities to minimise crime.'. This debate has been mainly centred on the relation between the dwelling and the public realm, that is, between the traditional dwelling direct relation to the public street and the changes on it as those provoked by the modern movement on architecture and urbanism (Hillier & Sahbaz 2005). For example, although some of the principles of Newman's Defensible Space may have been confirmed by space syntax studies (Hillier & Shu 2000, Hillier 2004 in Hillier & Sahbaz 2005, p.452) in certain circumstances, they have not in others, giving support this time to certain new urbanist propositions. That is, for example, considering residential burglary '...when embedded in an urban street network, simple linear cul-de-sacs can often be the safest places, but that when the cul-de-sac is generalised into a design principle so that whole areas take the form of a hierarchy of cul-de-sacs, the effects can be quite the opposite (Hillier and Shu 2000, Hillier 2004).'

Hillier & Sahbaz (2005, p.451) emphasizes that 'on the main strategic issues of grid versus tree-like layouts, public versus private space, developmental scale, permeability, mixed use and residential density evidence of the appropriate precision is sporadic and inconclusive'. Studies involving space syntax have contributed to the understanding of the effect of space variables on crime by considering the configuration of spaces in certain urban areas, without, however, negating this complex relationship, but on the contrary, revealing it. For example, in residential areas, '...the streets that are most integrated - and therefore with more natural movement- are often safer than the more broken up spaces, but that where integrated streets have 'local vulnerability', for example through 'secondary exposure' through alleys or adjacent open areas, or basement access, then integrated streets can become singularly vulnerable.' (Hillier and Shu 2000, Hillier 2004 in Hillier & Sahbaz 2005, p.452). However, Hillier & Sahbaz (2005, 452) remarks that '... space syntax has not so far studied patterns of crime either at the much larger scales of the city and its multiplicity of socially and spatially differentiated areas, or with a full analysis at the high resolution level of the street segment.' They (Hillier & Sahbaz 2005, p.452) add that 'What is needed is high resolution analysis of crime patterns in urban street networks in which these issues are variables to begin to build the body of evidence needed to decide these issues.'

Hence, the proposed high-resolution space syntax analysis where the unit of analysis is the segment of a street between junctions, in combination with Geographical Information Systems (GIS), developed by Hillier (2005) in his paper mentioned above is partially followed in this paper, since some of the variables are not dealt with here. Moreover, although many authors have dealt with the subject of security in Brazilian cities, the relationship between security and urban form and configuration has not been dealt with directly.

Therefore, this paper examines the relationship between configurational properties, such as axial lines integration levels and segments connectivity values, and different types of crimes, such as street robbery and residential burglary, in a Porto Alegre typically middle-income residential borough. Segment connectivity 'relates to

access and egress (and so to potential escape routes), and it is the key to the whole issue of grid-like versus tree-like layouts.' (Hillier & Sahbaz 2005, p.456).

Methodology

Data related to the occurrence of street robbery and residential burglary was collected for Menino Deus borough, in the Department of Public Security of Rio Grande do Sul State, for a period of ten months. This data was computed in ArcGIS, as a way of generating maps according to the different types of crimes, and allowing the visualization of spatial patterns of such crimes. Analysis of axial lines integration levels and segment connectivity values was carried out in Depthmap considering the axial map of the borough. The line segment map shows segmented axial lines, that is, axial lines broken into segments at each intersection. Segment connectivity normally has a value between 1, for the last segment in a cul-de-sac, and 6 for a grid like layout (Hillier & Sahbaz, 2005, p.456). Apart from connectivity some basic segment variables were also measured, such as: segment length; number of residential and non-residential units in each segment; linear density – number of dwellings over the length of the segment; ratio of residential to non-residential uses in each segment.

Since robbery means victims under threat, in the category street robbery it was included either pedestrian victim or people inside a vehicle. Moreover, as a way of making the sample larger for this category since there was a difficulty in getting the data for a larger period and part of the crimes had not been spatialised according to the block but only to the street (and so, preventing them from being related to connectivity values of segments) when they were registered in the Police Stations, it has also been included vehicle theft. It was also understood that the urban spatial characteristics leading to these criminal activities, would have common attributes since they would require, for example, less surveillance either from people on the streets or in adjacent buildings. Street robbery was measured considering Hillier & Sahbaz (2005, p.467) 'time risk' which takes into account the length of time a moving person spends on a segment, this being, a function of its length. Hence, 'time risk' for street robbery means the total number of robberies in segments belonging to a certain band (characterized, i.e., by intervals of 5metres for segments with 100 m or less, and by intervals of 10 metres for segments with 250m or more) divided by the total number of segments in such band.

Residential burglary was measured considering Hillier & Sahbaz (2005) the 'true rate for the risk bands', that is, the total number of burglaries over the total number of residential units for each band, each being made up by segments having a common number of dwellings, such as a band formed by segments with 1 dwelling or a band constituted by segments with 2 dwellings.

Results and Discussion

A large picture of spatial distribution of street robbery and residential burglary in the residential borough of Menino Deus reveals that the number of street robbery is much large than the number of burglary (Figures 1 and 2). Street robbery has a somewhat spread pattern apart from the concentration of dots representing robberies that were spatialised according to the street but not according to the segment, specifically in one major street in the Borough Menino Deus called Ipiranga Avenue, perhaps creating what Hillier & Sahbaz called 'hot lines' (2005, p.458). This would might mean that there is more robbery where there are more people (since Ipiranga Avenue is represented by integrated lines, with great potential of movement), what the

segment analysis will try to show more clearly in assessing robbery risk (Hillier & Sahbaz 2005). Residential burglary has a less dispersed pattern with a tendency to form clusters in some areas. Nonetheless, the fact that the number of spatialised crimes, either street robbery or residential burglary, is not that big, makes the picture about their distribution less clear.

025-04



Relationship between Segments Connectivity Values and Street Robbery

Street robbery is considered using Hillier and Sahbaz (2005) methodology of 'time risk' as previously explained. In Menino Deus, street robbery, as expressed by 'time risk' bands, tend to increase with increase in segment connectivity (Figure 3; Figure 4) until the connectivity value of 4 and then to stabilize between the connectivity values of 4 and 6. This suggests that the risk of being robbed on the street in Menino Deus is greater in higher connected than in lower connected streets. Taking the assertion that 'Robbers use more connected segments when there are fewer people around.' (Hillier & Sahbaz 2005, p.471, 473) it might be conjectured that movement of people on streets in Menino Deus is not that intense. Moreover, segment length may also affect the effect of connectivity on burglary and so, on street robbery as well. As mentioned by Hillier & Sahbaz (2005, p.477):

'...in many instances, high street connectivity in a more grid like layout is associated with low crime where the numbers of dwellings of segment are sufficiently large. If urban blocks are too small, so that there are fewer dwelling per segment - that is between the escape routes - then burglary tends to increase.'

Moreover, they assert that:

'Both burglary and robbery occur on average on less connected spaces than average. The 8 top robbery segments, which form .01% of the segments but which account for 4% of the robbery, have a mean connectivity of 3.625, well below the average for all segments of 4.16. 6-connected segments have lower average rates of robbery than 3-, 4- or 5- connected spaces.' (Hillier & Sahbaz 2005, p.477).

Figure 1:

Spatial distribution for street robbery in Menino Deus (left)

Figure 2:

Spatial distribution for residential burglary in Menino Deus (right)



Looking at the results for Menino Deus (characterized by a grid layout in most of its area), the 6 top robbery segments, which form 2.3% of the segments (total of 261), account for 19.6% of the robbery (total of 378), and have a mean connectivity of 5.33, well above the average for all segments of 4.78. Moreover, 6-connected segments have higher average rates of robbery (2.5 robberies per segment) than 5-connected spaces (1.30), these have higher average rates of robbery than 4- connected spaces (1.01), and these than 3- connected spaces (0.64). Then, why such apparent contradiction? Taking into consideration the effect of segment length and number of dwellings on connectivity, the explanation for higher connected segments being associated with higher rate of robbery might be related to blocks being too small with few dwellings per segment, as mentioned by Hillier & Sahbaz (2005). However, it was found that as much segment length (3- 97,7m; 4- 105,58m; 5- 120,93m; 6-155,01m) as the number of dwellings (3- 30; 4- 47,9; 5- 67,2; 6- 75,5) per segment increases from

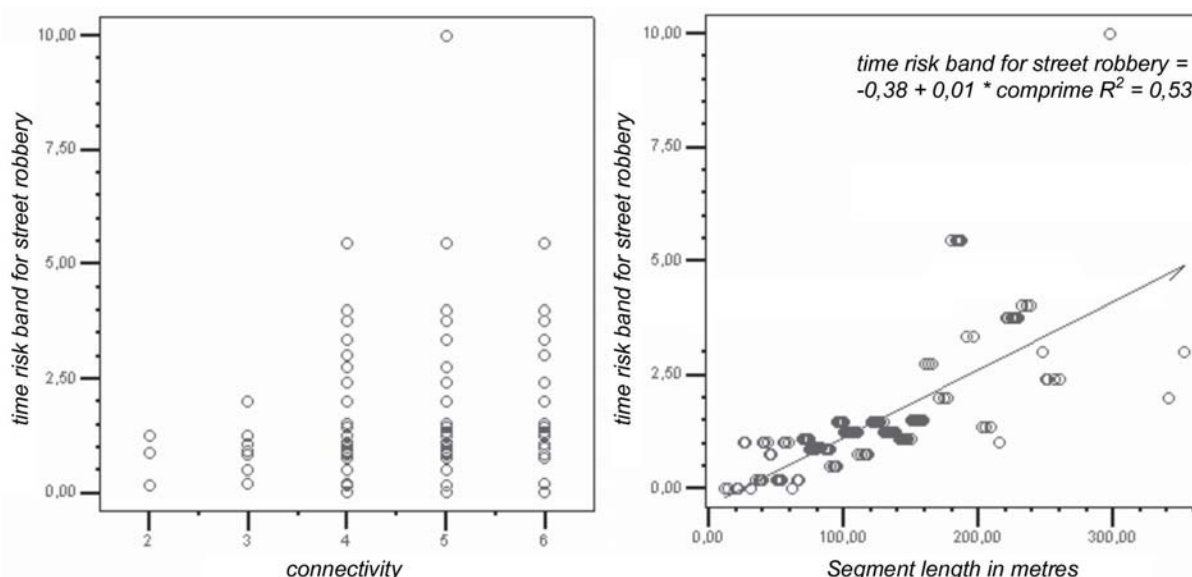
Figure 3:

Segments connectivity in the area including the borough of Menino Deus

Note: map based on the axial map of Porto Alegre by Decio Rigatti

025-06

3- to 6- connected segments. Therefore, a plausible explanation might be related to dwelling type. Whereas the London borough, where Hillier & Sahbaz (2005) did their research, tend to be characterized by semi-detached houses, terraced houses, converted flats, and flats in commercial buildings, the borough of Menino Deus (with an area of 215 hectare and a population of 29.577 inhabitants in 2005) is constituted by many blocks of flats, expressed in its density of 138 inhabitants per hectare (City Council: Planning Department; <http://www2.portoalegre.rs.gov.br/spm>), much higher than Três Figueiras (34 inhabitants/ha), a typical residential borough in Porto Alegre characterized by detached houses. Hence, while in the London borough most of the dwellings have direct access to the street, with front doors facing the streets, in the Porto Alegre borough of Menino Deus they do not have. This may suggest that the benefits of having many dwellings in a segment has been lost or partially lost due to the change in the relationship between the dwelling access and the public space. In this respect, higher linear density does not mean safer segments (linear density = number of dwellings over segment length: 6 – 0,478; 5- 0,531; 4- 0,503; 3- 0,331). 3- connected segments present the lower linear density and the lower rate of robbery compared to 4-, 5- and 6- connected segments. Nonetheless, in this on going research it shall be checked the number of dwelling type per segment.



Segment Length and Street Robbery

The relationship found between segment length and street robbery (Figure 4) as represented by 'time risk bands' (the number of robberies within each band divided by the number of segments) in the residential borough of Menino Deus is consistent with Hillier and Sahbaz (2005, p.468), showing that rate rises consistently with increasing length (Figure 4), giving further support to the fact '...that the time spent on a segment in moving through it is indeed a primary risk factor' (Hillier and Sahbaz 2005, p.468). This helps to explain why 6- connected segments, which present the longest segments are those also with the highest rate of street robbery, and the 3- connected segments, which present the shortest segments are those with the lowest rate of robbery.

Figure 4:

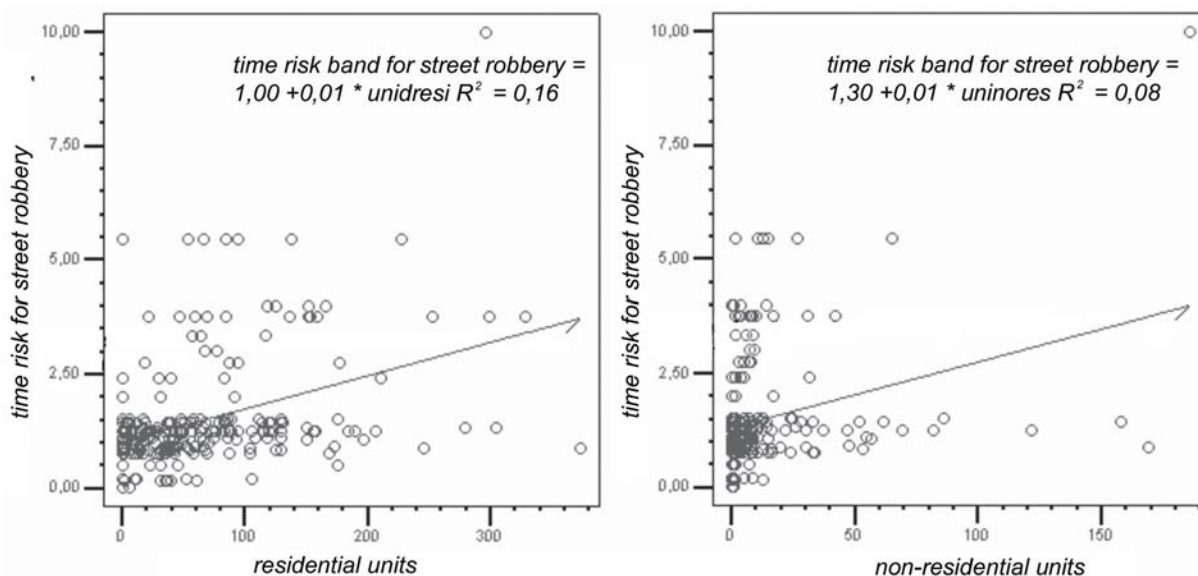
Segments connectivity(left) and length, and street robbery in the residential borough (right) of Menino Deus

Number of Residential Units in the Segment and Street Robbery

The analysis of the relationship between number of residential units and street robbery (as represented by time risk bands; Figure 5) shows a tendency for the risk of being robbed to increase as the number of residential units increases. This appears to contradict the say that:

'The critical thing is that the more residential outweighs non-residential the better it tend to get. There is more crime in and around urban centres at all scales ... and where this leads to isolated dwellings, or dwellings with very few neighbours, then this is associated with higher burglary... Robbery rates are likewise higher in and around centres, but less than the increase in movement rates, so risks are reduced during the times when movement levels are good. Main streets are dangerous without good movement rates, as they are late at night, but when movement rates are good, the less integrated and less connected spaces associated with centres are the dangerous places.' (Hillier & Sahbaz 2005, p.477).

Again it can be conjectured that a possible explanation lies on the fact that residential units in Menino Deus are largely characterized by of block of flats, changing the traditional urban relationship between the dwelling and the open space.



Number of Non-Residential Units in the Segment and Street Robbery

The analysis of the relationship between number of non-residential units and street robbery (as represented by time risk bands; Figure 5) shows again that the risk of being robbed increases as the number of non-residential units increases in the segments in Menino Deus. Since '...segments with non-residential uses will in most circumstances be associated with higher movement rates, especially retail and similar movement dependent uses' (Hillier & Sahbaz 2005, p. 469), it can be suggested from the previous results that more movement means more street robbery. However, according to London data base analyzed by Hillier & Sahbaz (2005, p.468) movement rate on segments with retail is 4.042 times those on segments without, while the average robbery rate for segments with non residential uses is 2.4 times the rate on segments without non-residential uses, meaning that rate of increase in robbery is considerably less than the increase in movement rates, that is, that people is '...68% safer on busier street segments with non

Figure 5:

Residential and Non-Residential units (left) and street robbery (right) in the residential borough of Menino Deus

residential uses than on those without.' Nonetheless, it may be the case that there is an increase in target on the streets but not on surveillance of such target by people in the buildings due to the dwelling type (block of flats) prevailing in many streets in Menino Deus. The possible negative effects produced by the break on the relation between dwellings and the street have been remarked by (Hillier & Sahbaz 2005, p.478): 'It has always been, and remains, unclear how breaking the link between residence and the street, as implied by the universalisation of the residential enclave, can lead to anything but an increasingly insecure public realm of our cities.' Moreover:

025-08

'On robbery, the ratio of dwellings to non-residential uses, which is associated with reducing robbery rates, also correlates strongly with residential density ... though much less strongly in the higher density areas. But the trend is still beneficial. There is no evidence, in this or other syntactic studies, that it brings other disadvantages.' (Hillier & Sahbaz 2005, p. 477).

Relationship Between Segments Connectivity Values and Residential Burglary

Residential burglary has been calculated, following Hillier and Sahbaz methodology (2005, p.465), using the 'true rate for the risk bands' as previously explained. The graph (Figure 6) shows that as integration of axial lines containing the segments in the borough of Menino Deus increases the true rate for the risk band slightly decreases. This is consistent with Hillier and Sahbaz findings concerning '...integrated residential areas, where there are many line neighbours.' and where burglary rate is low (2005, p.465). Splitting the bands more or less evenly between the lower and higher residence bands and plot them separately Hillier and Sahbaz (2005, p.465, 466) found that:

'...while for the low residence bands more integration means more burglary, for the high residence bands more integration - and so more natural movement - means less burglary, though less strongly. This would seem to explain why in previous studies of residential areas integration was generally found, other things being equal, to be associated with lower rates of burglary.'

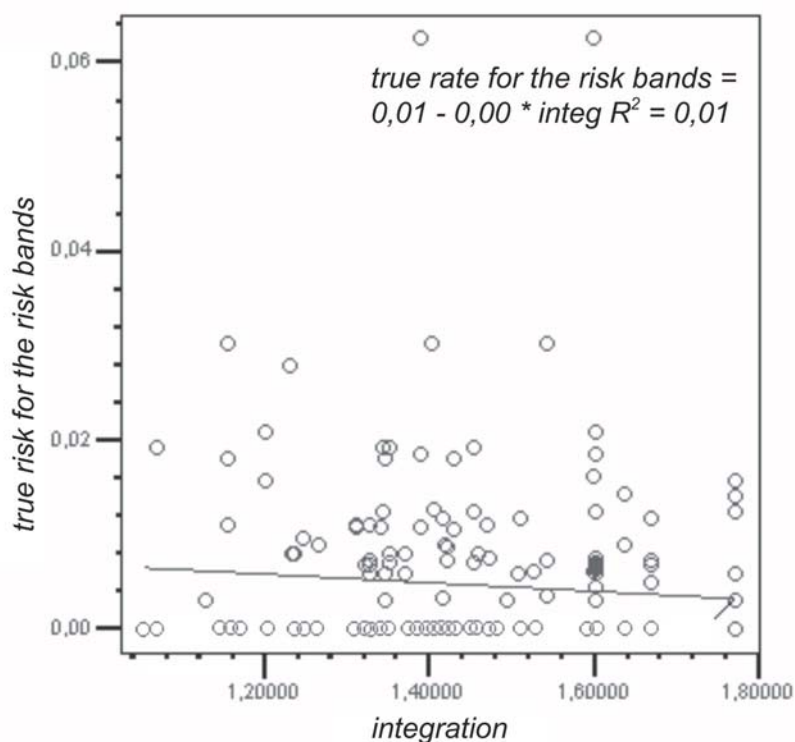
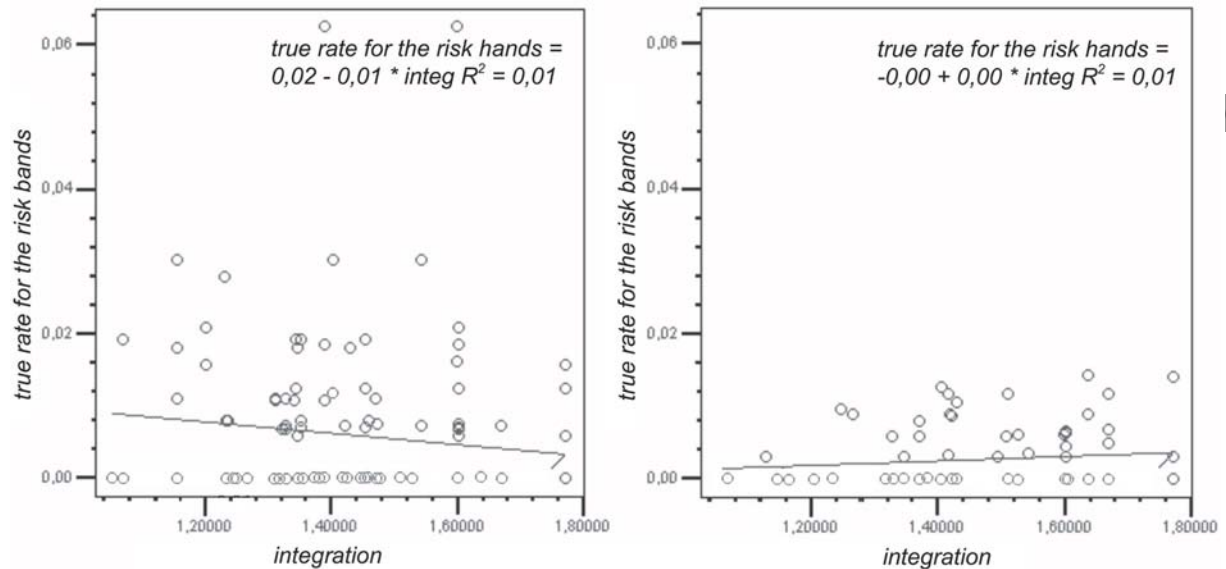


Figure 6:
Global integration and rate of Burglary

Nonetheless, the replication, using the data for Menino Deus, of the plotting of integration with low (from 0 to 68 residential units in the segment, corresponding to 63 bands) and high residence bands (from 69 to 374 residential units in the segment, corresponding to 63 bands) did reveal opposite results. While burglary rate of lower residence bands (Figure 7) decreased with increase in integration, burglary rate of higher residence bands (Figure 7) slightly increased with increase in integration.



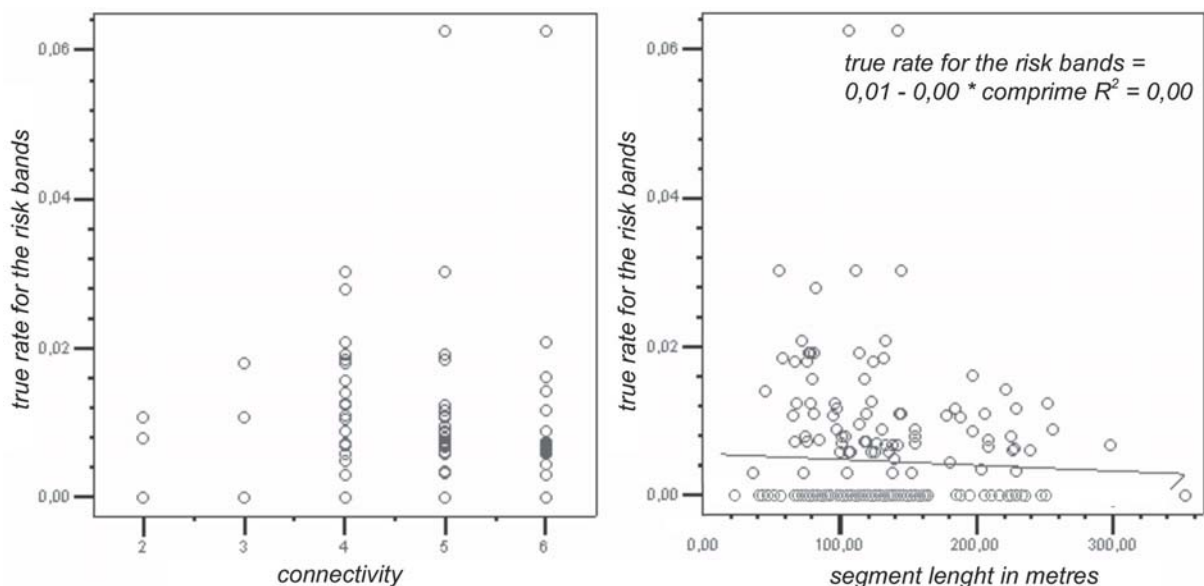
025-09

Segment Connectivity Levels and Residential Burglary

Although Hillier & Sahbaz (2005, p.468) pointed out that 'Integration and segment connectivity are beneficial in more grid-like residential areas, but not in high street areas where dwellings are sparse and vulnerable.' results show that residential burglary in the residential borough of Menino Deus tends to increase according to increase in segment connectivity levels (Figure 8).

Figure 7:

Burglary rate and integration of lower (left) and higher (right) residence bands



Segment Length and Residential Burglary

Residential burglary in the residential borough of Menino Deus tends to decrease as segments length increases (Figure 8). This might be related to the fact that as segment length increases the number of

Figure 8:

Segment connectivity and length (left), and residential burglary (right)

escape routes decreases, decreasing opportunity for burglars to escape and so discouraging them to commit residential burglary.

Number of Residential Units in the Segment and Residential Burglary

Results (Figure 9) show that the number of residential units in the segment does relate to residential burglary in the residential borough of Menino Deus, giving support to the assertion that 'having more neighbours helps to keep you safe' (Hillier & Sahbaz 2005, p.465).

025-10

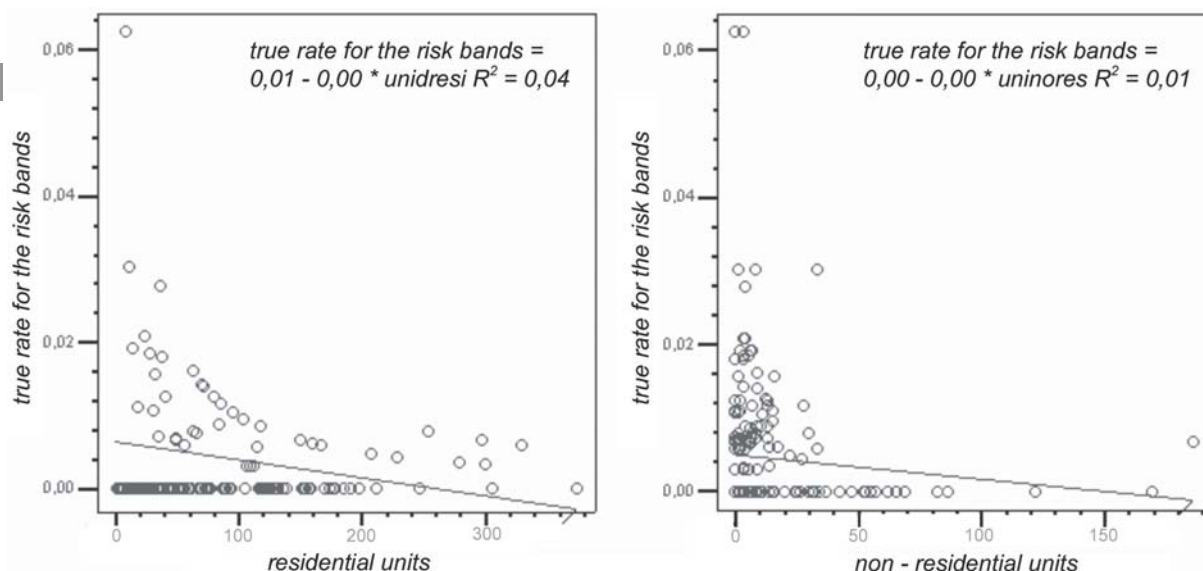


Figure 9:

Residential (left) and Non-residential units and residential burglary (right)

Number of Non-Residential Units In the Segment and Residential Burglary

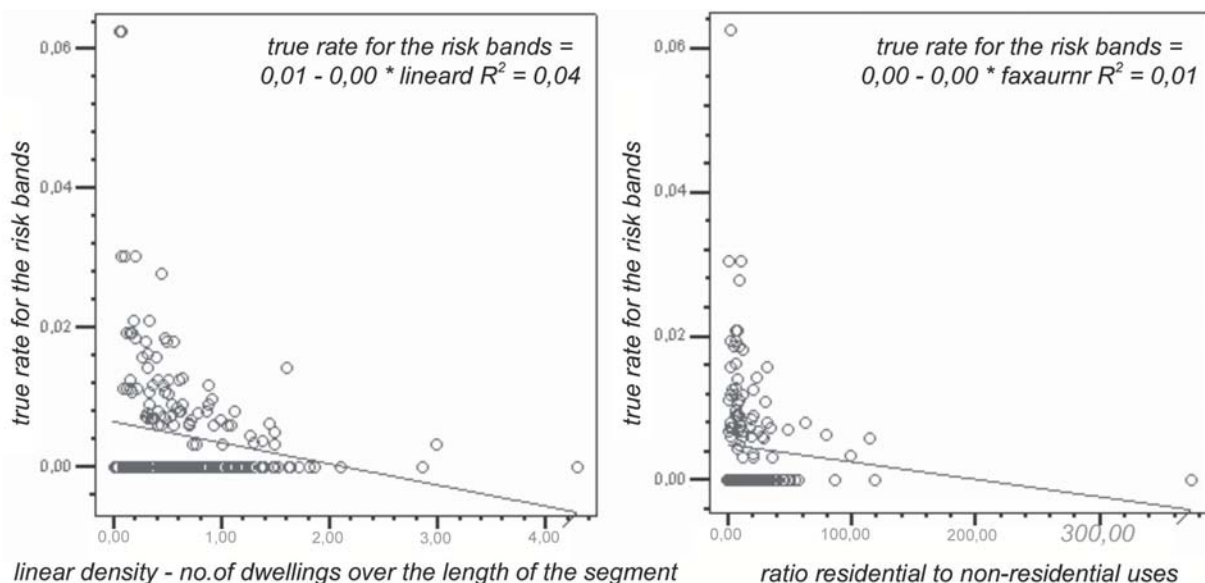
Residential burglary as expressed by the true rate for the risk bands in Menino Deus, tend to slightly decreases as the number of non-residential units increases (Figure 9). This may appear contradictory to the fact that in 'high street areas, where there are few dwellings because most units are non-residential and burglary rates are among the highest' (Hillier & Sahbaz 2005, p.465). Nonetheless, it may be explained by the borough of Menino Deus being typically residential [with residential units in 83, 14% (217) of the total of 261 segments and 76,25% (199) of the segments having at least 10 residential units] and by the local non-residential units acting as controller of movement and visitors in the area.

Linear Density and Ratio of Residential to Non-Residential Uses in the Segment and Residential Burglary

The findings clearly show the positive effect of linear density (number of dwellings over the length of the segment) on burglary (Figure 10). These are in line with the assertion that '... wherever residential density has been looked at as a variable, higher densities has been largely beneficial. On burglary, the increase in the number of dwellings per segment, which correlates with reducing rates of burglary, also correlates very strongly ... with density...' (Hillier & Sahbaz 2005, p.477). Moreover, '... higher density is associated with lower burglary rates independent of house type.' (Hillier & Sahbaz 2005, p.467).

It is also examined the relation between burglary and the ratio of residential to non-residential uses (Figure 10), another basic segment variable which '... correlates with the numbers of dwelling per segment and so correlates also with reducing burglary rates' (Hillier & Sahbaz 2005, p.467). This ratio and linear density '... correlate with

reducing crime more strongly than the simple number of dwellings... although they are not independent from the number of dwellings in the segment (Hillier & Sahbaz 2005, p.467). Results confirm the positive effect of ratio of residential to non-residential uses in decreasing burglary rates. Hillier & Sahbaz (2005, p.468) points out that research suggests that '...it is the degree to which residential units outnumber non-residential that is critical. It also points again to the high vulnerability of small numbers of dwellings in strongly non-residential areas.'



025-11

CONCLUSION

Apart from apparently some contradictory findings, mainly concerning street robbery, which need deeper investigation, the interpretation of these initial results indicate that increase in either residential or non-residential units in a segment decrease residential burglary having the ratio of residential to non-residential uses in favour of residential units. The number of residential units in a segment, either in through streets or in cul-de-sacs, was mentioned by Hillier & Sahbaz (2005, p.475) as a main finding in their study, saying that: 'In residential areas, the more dwellings that lie on street segment between junctions then, other things being equal, the safer you are from both burglary and robbery.'

Some progress in the understanding of the complex relationship between street robbery and residential burglary and configurational attributes of residential urban areas can be made from these results. This understanding may allow in the future, the consideration of urban configuration as playing a role in urban security. Moreover, is less difficult and expensive to prevent crime through measures carried out in the design of residential areas than to implement changes latter on, after these areas have been built.

The level of criminal activities in many Brazilian urban areas is high comparing to many cities around the world including some cities in neighbouring Latin-American countries, what makes this type of research even more important. Such level of crime appears to have affected the use of urban space, what Hillier & Sahbaz (2005, p.478) call residential culture:

A residential culture, it might be conjectured, is first a culture of civilized co-presence, and only second, and after due time, a culture of community formation. This, perhaps, is what made historic cities, which always brought heterogeneous population into dense patterns

Figure 10:

Linear Density and ratio of residential to non-residential units (left) and residential burglary (right)

of contact, the civilised places they seemed to be. As both Jane Jacobs and Oscar Newman observed, a society that does not civilise its streets cannot be civilised.

In general, movement of people in urban areas can produce more natural surveillance (reducing crime) but can also attract potential criminals. A residential culture would guarantee the reduction of crime risk (Hillier & Sahbaz 2005, p.478). But it seems that this residential culture would largely depend, in turn, on 'the presence of good numbers of dwellings on streets, and the fulfilling of certain design condition such as the sizing of blocks, the structuring of permeability, and maintaining a high ratio of residence to non-residence where uses are mixed.' (Hillier & Sahbaz 2005, p.478).

025-12

A work to be done next is the consideration of constitutedness and time of the day, apart from crime as identified by the residents and their perceptions about security in these residential boroughs. As mentioned by Hillier & Sahbaz (2005, p.474) referring to their research:

Although this is only the first stage of the research, we see that the inter-dependence of crime and space is much more complex and variable than is often believed. The results offer hope that with a more precise understanding of the relation between urban spatial dynamics and different kinds of crime, it will be possible to develop a more sophisticated approach to how to design city areas for urban levels of use without incurring penalties in terms of increased crime.

Acknowledgements; This investigation was carried out with financial support from CNPq (National Council of Scientific and Technological Development), a Brazilian governmental institution sponsor of Scientific and Technological Development.

REFERENCES

- Jacobs, J., 1961, *The Death and Life of Great American Cities*, Random House, New York.
- Hillier, B., Sahbaz, O., 2005, "High Resolution Analysis of Crime Patterns in Urban Street Networks: An Initial Statistical Sketch from an Ongoing Study of a London Borough", A. van Nes (Ed.), *Proceedings*, 5th International Space Syntax Symposium, Delft, Netherlands, pp.451-478.
- Hillier, B., Shu, S., 1999, *Do Burglars Understand Defensible Space? New Evidence on the Relation Between Crime and Space*. <http://www.spacesyntax.org>.
- Newman, O., 1972, *Defensible Space – Crime Prevention Through Urban Design*, The Macmillan Company, New York.
- Poyner, B., 1983, *Design Against Crime - Beyond Defensible Space*, University Press, Cambridge.
- Reis, A., Portella, A., Bennett, J., Lay, M., 2003, "Accessibility and Security: Syntactic and Perceptual Analysis in Two Low-Income Housing Estates", *Proceedings*, 4th International Space Syntax Symposium, vol. II, London, pp. 44.1- 44.12.
- Shu, S., Huang, J., 2003, "Spatial Configuration and Vulnerability of Residential Burglary: A Case Study of a City in Taiwan", *Proceedings*, 4th International Space Syntax Symposium, London, England, pp.46-1- 46-14.
- Voordt, D., Wegen, H., 1990, "Testing Building Plans for Public Safety: Usefulness of the Delft Checklist", *Netherlands Journal of Housing and Environmental Research*, vol.5, n.2, pp.129-154.