EFFECTS OF SOME SEGMENTS FEATURES ON RESIDENTIAL CRIME IN TWO BOROUGHS

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Abstract

This paper's objective is the investigation of the relationship between the occurrence of robberies and burglaries in homes in four different periods of the day (each period with six hours, starting at 6:00 a.m.) and physical spatial variables such as segment length, connectivity, integration, choice, topological depth from the main route, dwelling types (houses or buildings with three or more floors) and land use (residential or non-residential) in the segments. It is analyzed the occurrence of crimes in homes in working days and weekends, in different month of the year (and so, the different seasons) and during the years from 2006 to 2010, in two residential boroughs in Porto Alegre, namely, Menino Deus and Rio Branco. Data regarding the occurrence of robberies and burglaries in homes were collected in the Department of Public Security of the State of Rio Grande do Sul for a five years period. This data were initially tabulated in ArcGIS and related to each segment, and later transferred to SPSS/PC. Segment attributes were obtained through the analysis in Depthmap of segment map obtained from the axial map of the two boroughs, and later transferred to SPSS/PC. Data regarding dwelling type and land use were collected in the Department of City Planning and tabulated in SPSS/PC. Data analysis included Pearson correlations tests between rates of robberies and burglaries in homes, in each of the four periods of the day, and the physical spatial variables considered in the study. Results show, for example, that robberies in homes tend to occur in the morning, afternoon and during dawn period, being kept to a minimum at night period. This tends to be repeated for the occurrence of burglaries (that are much larger in number than the robberies), which are reduced almost to half during night period in comparison to the number of burglaries in the each of the other three periods. Levels of integration and choice of the segments were not correlated with rates of robberies and burglaries in each of the four periods in Menino Deus Borough and in Rio Branco Borough, with the exception for the correlation between residential burglary rate in the morning and level of integration and choice of segments, as well as the negative correlation between the residential robbery rate during the dawn period and level of segment integration in Rio Branco Borough.

Keywords: *crimes in homes, segment length, segment connectivity, integration, choice*

Theme: *Urban Space and Social, Economic and Cultural Phenomena*

INTRODUCTION

Crime is related to many aspects including social-economic, political, pathological and environmental ones. Crime prevention through environmental design has been of interest of many authors (Van Nes and López 2010; Hillier and Sahbaz 2005; Hillier and Shu 2000; Clarke 1997; Poyner and Webb 1991; Newman 1972; Jacobs 1961), and since early sixties the importance of physical and spatial characteristics of urban areas in affecting the occurrence of crime has been pointed out by Jane Jacobs (1961). Knowledge about the relationship has been produced, regarding the impact of some physical, spatial or environmental variables. For example, studies have shown that urban configuration tends to have an effect on the occurrence of crime in distinct urban settings (i.e. Shu 2009; Hillier and Sahbaz 2012; Hillier and Sahbaz 2005). In this sense, residential burglary distribution patterns were found to be affected by road types, degrees of road accessibility, and, particularly, by dwellings' front door to front door inter-visibility. Segregated roads (characterized by low accessibility of passers-by and vehicles) were more vulnerable to residential burglary than integrated ones (characterized by high accessibility of passers-by and vehicles), especially, when characterized by low inter-visibility, while higher accessible streets with good dwellings' front door to front door inter-visibility tended to be very safe from residential crime (Shu 2009).

Nonetheless, it is necessary to deepen the existing knowledge in order to have a more clear idea about the effect of such variables regarding different types of crimes in different periods of the day. It is necessary to treat the crime data according to its temporal distribution since, for example, potential of movement, as represented by integration of segments, visual supervision from the buildings to the open spaces and public light in the streets may have different effects on crime during the day compared to night and dawn periods. Moreover, it is necessary to analyse the relationship between physical, spatial or environmental variables and specific crimes, during the periods of the day. At least in the case of Brazilian large cities there is no conclusive evidence to support the impact on residential crime, specifically on residential robbery (means burglary in residences involving threat of or actual violence to residents) and residential burglary (residents are not present), of variables such as segment length, connectivity, integration, choice, topological depth from the main route, dwelling types (houses or buildings with three or more floors) and land use (residential or non-residential) in the segments. Additionally, there is no information about the occurrence of crimes in homes in working days and weekends, in different month of the year (and so, the different seasons) and during the years from 2006 to 2010, for a large city such as Porto Alegre, in Brazil. The importance of investigating residential crime has already been acknowledged, being a type of crime with one of the highest incidence in urban areas (i.e., Shu 2009).

Therefore, this paper's objective is the investigation of the relationship between the occurrence of robberies and burglaries in homes in four different periods of the day (morning, afternoon, night and dawn) and physical spatial variables such as segment length, connectivity, integration, choice, topological depth from the main route, dwelling types (houses or buildings with three or more floors) and land use (residential or non-residential) in the segments. It is analyzed the occurrence of crimes in homes in working days and weekends, in different months of the year, and during the years from 2006 to 2010, in two residential boroughs in Porto Alegre, namely, Menino Deus and Rio Branco.

METHODOLOGY

The two residential boroughs can be described as being mainly comprised of fenced or walled houses or blocks of flats in less crowded streets, and by non residential buildings (i.e. offices,

commerce and services) or mixed-use buildings in main busiest streets (Figures 1 and 2), which concentrate much of the tallest buildings and those with non-residential uses such as bars, restaurants and supermarkets, that promote movement and presence of people at night. Two storey buildings predominates in both boroughs (with taller buildings being less common) and residential buildings predominates over non-residential buildings. Data regarding the occurrence of robberies and burglaries in homes in Menino Deus and Rio Branco boroughs were collected in the Department of Public Security of the State of Rio Grande do Sul for a five years period, from 2006 to 2010. Crime records in this Department are a result of crime occurrences registered in Police Stations according to residential addresses of such occurrences.

In Menino Deus Borough, during the five years (2006 to 2010), there were 13 residential robberies incidents and 133 residential burglaries in a total of 146 residential crimes in 221 segments with the total length of 28,1km. In Rio Branco Borough there were 19 residential robberies and 79 residential burglaries in a total of 98 residential crimes in 175 segments with the total length of 21,8km. Density of residential crimes per number of segments (number of residential crimes by the number of segments) in Menino Deus is 0,66 (146/221) and in Rio Branco is 0,56 (98/175). Density of residential crimes per total segments length (number of residential crimes by the total length of segments) in Menino Deus is 5,19 crimes/km (146/28,1km) and in Rio Branco is 4,49 crimes/km (98/21,8km). Moreover, density of residential crime per number of residential access indicates (number of residential crimes by the number of residential access) in Menino Deus is 0,077 (146/1884) while in Rio Branco is 0,060 (98/1633). Therefore, the occurrence of residential crime is slightly higher in Menino Deus than in Rio Branco and the number of residential burglary is far greater than the number of residential robbery in both boroughs (Table 1). Hence, due to the small sample of residential robberies in Menino Deus and in Rio Branco, and to the consideration of the temporal distribution of crime in four different periods of the day (morning, afternoon, night and dawn), residential robbery and residential burglary are only individually analyzed for the total sample of 396 segments in both boroughs. Residential crime (residential robbery + residential burglary) is analyzed for the total sample and for each of the two boroughs. Therefore, correlations (Pearson) were made: between segments features and residential crime rate for the whole day and for each period of the day, considering the whole sample and each of the two boroughs; between segments features and residential robbery rate for the whole day and for each period of the day, considering the whole sample; and between segments features and residential burglary rate for the whole day and for each period of the day, considering the whole sample.

Table 1 Distribution of residential crime, residential robbery and residential burglary incidents

	396 segments in both boroughs	221 segments in Menino Deus	175 segments in Rio Branco
Residential Robberies during the morning	11	4	7
Residential Robberies during the afternoon	9	4	5
Residential Robberies during the night	1	0	1
Residential Robberies during the dawn	11	5	6
Total of Residential Robberies	**32**	**13**	**19**
Residential Burglaries during the morning	56	30	26
Residential Burglaries during the afternoon	64	44	20
Residential Burglaries during the night	31	16	15
Residential Burglaries during the dawn	61	43	18
Total of Residential Burglaries	**212**	**133**	**79**
Total of Residential Crimes (Robberies + Burglaries)	**244**	**146**	**98**

Note: although there were 275 segments in Menino Deus e 200 segments in Rio Branco (475 segments in both boroughs) 79 segments were excluded since there were no residential access in these segments (no address number) and so, no residential crime incident was registered in these segments at the police stations before crime related data were sent to the SSP.

A map of street segments (defined by intersecting axial lines) was generated in the Depthmap software from the axial map representing the street network of the two boroughs, in order to consider the street segment as the unit of analysis. The axial map of Porto Alegre was used for each case study (Menino Deus and Rio Branco Boroughs) taking account of a larger contextual area in order to eliminate problems of edge effect.

Crime data were initially tabulated in ArcGIS and related to each segment and later transferred to SPSS/PC. Therefore, a high resolution analysis on the level of a street segment was considered using Depthmap (Turner 2004). Segment attributes were obtained through the analysis in Depthmap of segment map obtained from the axial map of the two boroughs, and later transferred to SPSS/PC. As highlighted by Hiller and Iida (2005) segment analysis has the advantage over axial line analysis in being more detailed and producing better correlation with movement analysis.

Data regarding dwelling type and land use were collected in the Department of City Planning and tabulated in SPSS/PC. Data analysis included Pearson correlations tests between residential crime rates (for the total sample, for Menino Deus and for Rio Branco), residential robberies rates (only for the total sample), and residential burglaries rates (only for the total sample), in each of the four periods of the day (each period with six hours, starting at 6:00 a.m.), and for the whole day, true risk band rate (for the total sample, for Menino Deus and for Rio Branco), and the physical spatial variables considered in the study: segment length; segment connectivity (measures the number of connections of a segment to other segments, varying from 1 to 6); segment integration (measures how accessible a segment is from all the others, and so, its destination potential); segment choice (measures the potential of a segment be chosen as part of a route to reach a certain destination); topological depth of a segment from the main routes; dwelling types (houses or residential buildings with three or more floors) and land use (residential or non-residential buildings) in the segments.

Integration and choice were measured taken into account global (all the segments in the borough were considered) and local radius (only segments within a radius of 750 metres were considered). Other walkable distances weren't considered in this study due to Hillier's argument that:

"We would expect local movement to be best accounted for by a local radius choice measure – 800 metres is the current favourite with space syntax limited …. Larger scale movement such as vehicular movement should best be reflected in a higher radius measure." (Hillier 2007, p.2).

Topological depth of a segment from the main routes was considered by selecting the main routes in each borough (Figures 1 and 2) accordingly to their global and local choice value and by the knowledge about the main streets in each borough. In order to count the number of houses, residential buildings with three or more floors, and non-residential buildings (i.e. offices, shops, bar/restaurants, and services, without regard to their periods of operation) in each segment, it was considered the number of main ground floor access to buildings (1 main access = 1 postal address) in each segment, as already considered in other studies (i.e. Shu 2009). Therefore, a 10 storey block of flats was counted as having one (1) main ground floor access as was a house with one or two floors. In addition, a building with a residential access and a shop

on ground floor was counted as having one (1) residential access and one (1) business access. Hence, what matters is the ground floor access to a residential building, and not to each flat, since how the burglar access the residence from the public open space is what is crucial.

Residential crime rate was measured by dividing the total number of crimes (robberies plus burglaries) in a segment by the number of residential access in that segment. Residential robbery rate and residential burglary rate were calculated in the same way, respectively considering the number of residential robberies and the number of residential burglaries in the segment. Therefore, each segment has its specific rate of total residential crime, residential robberies and residential burglaries, allowing for comparisons with physical spatial variables in the segment. Residential crime was also considered through the "true risk rate for the bands", which is the result of the total number of crimes in segments with an equal number of residential units (characterizing a band, like a band made up of segments with five residential units) divided by the total number of residential units in such segments (Hillier and Sahbaz 2005). Nonetheless, it is necessary to understand that this measure indicates the mean rate of residential crimes for a specific band (i.e. for a band constituted by segments with five residential units) and not crime rate for a specific segment. Therefore, the "true risk rate for the bands" tell us about the relationship between residential crime risk and segments constituted by a specific number of residential units, about the greater or smaller risk of a residential unit been a crime target in segments with larger or smaller number of residential units, but not about the residential crime risk of a specific segment.

RESULTS

Although, from 2006 to 2010, the total number of crimes in residences (244 robberies and burglaries), in both boroughs, had decreased from 61 (2006) to 52 crimes (2010), it has not happened in a progressive way but rather in an irregular pattern. This pattern tends to be specifically observed in relation to robberies (means burglary in residences involving threat of or actual violence) and burglaries. Nonetheless, the number of burglaries is far greater than the number of robberies in every year and every period of the day (morning; afternoon; night; and dawn), but both types of crime clearly decreased during the night period (from 6 p.m. to midnight). Yet, there is a clear tendency for an increase in residential crime during the summer vacations months, namely January (28 crimes) and February (35 crimes), and for a decrease in winter months of June (15) and July (12). This result can be explained by the fact that burglaries, which happen in vacant homes, respond for most of residential crimes. Regarding the temporal distribution of residential crimes during the week, there is a clear tendency for residential burglary to decrease in day Sunday.

Relationship between the occurrence of residential crime, robberies and burglaries in homes and segment length

Either for the total sample of segments in both boroughs (396 segments), or only for the segments in Menino Deus (221) or for the segments in Rio Branco (175), no correlations between residential crime (residential robbery + residential burglary) rate, either for each period of the day (morning, afternoon, night and dawn) or the whole day, and segment length were found. In general (the total sample of 396 segments), segment length was not correlated either to residential robbery rate (for the whole day or for each period of the day) or to residential burglary robbery rate (for the whole day or for each period of the day). On the other hand, either in general (Pearson, coef.= -0,288, sig.=0,000), in Menino Deus (Pearson, coef.= -0,160, sig=0,018), or in Rio Branco (Pearson, coef.= -0,226, sig=0,003), negative correlations between 'true risk rate for the bands' (considering residential crime for the whole

day) and segment length were found. This indicates that the lengthier the segment was the lower the 'true risk rate for the bands'.

Relationship between the occurrence of robberies and burglaries and segment connectivity

Either in general (the whole sample of 396 segments in the two boroughs), in Menino Deus or in Rio Branco no correlation between residential crime rate (residential robbery + residential burglary) for each period of the day and for the whole day and segment connectivity was found. In general, no correlations between residential robbery rate (either for the whole day or for each period of the day) and segment connectivity was found, with exception of a negative correlation (Pearson, coef.= -0,102*, sig.= 0,043) in the morning period, suggesting that homes in less connected segments are easier target to robbery in the morning than homes in more connected segments.   In general, no correlations between residential burglary rate (either for the whole day or for each period of the day) and segment connectivity was found.   Either in general or for each of the two boroughs no correlation between 'true risk rate for the bands' (considering residential crime for the whole day) and segment connectivity was found.

Relationship between the occurrence of robberies and burglaries and segment global and local integration

Either in general or for each of the two boroughs, no correlations between residential crime rate (residential robbery + residential burglary), either for each period of the day or the whole day, and segment global and local integration (R 750 metric) was found. In general, no correlation between residential robbery rate (either for the whole day or for each period of the day) and segment global and local integration was found. In general, no correlation between residential burglary rate (for the whole day and for each period of the day) and segment global and local integration was found, with the exception of a correlation between residential burglary rate for the morning period and segment global integration value (Pearson, coef.= 0,104, sig.= 0,039). This indicates that the more globally integrated the segments are the greater the possibility of homes becoming targets for burglary in the morning period. Correlations between 'true risk rate for the bands' (considering residential crime for the whole day) and segment global integration, in general (Pearson, coef.= 0,103, sig.=0,041) and in Menino Deus (Pearson, coef.= 0,155, sig.=0,021), were found. Correlation between 'true risk rate for the bands' (considering residential crime for the whole day) and segment local integration was only found for the whole sample of 396 segments (Pearson, coef.= 0,108, sig.= 0,032).
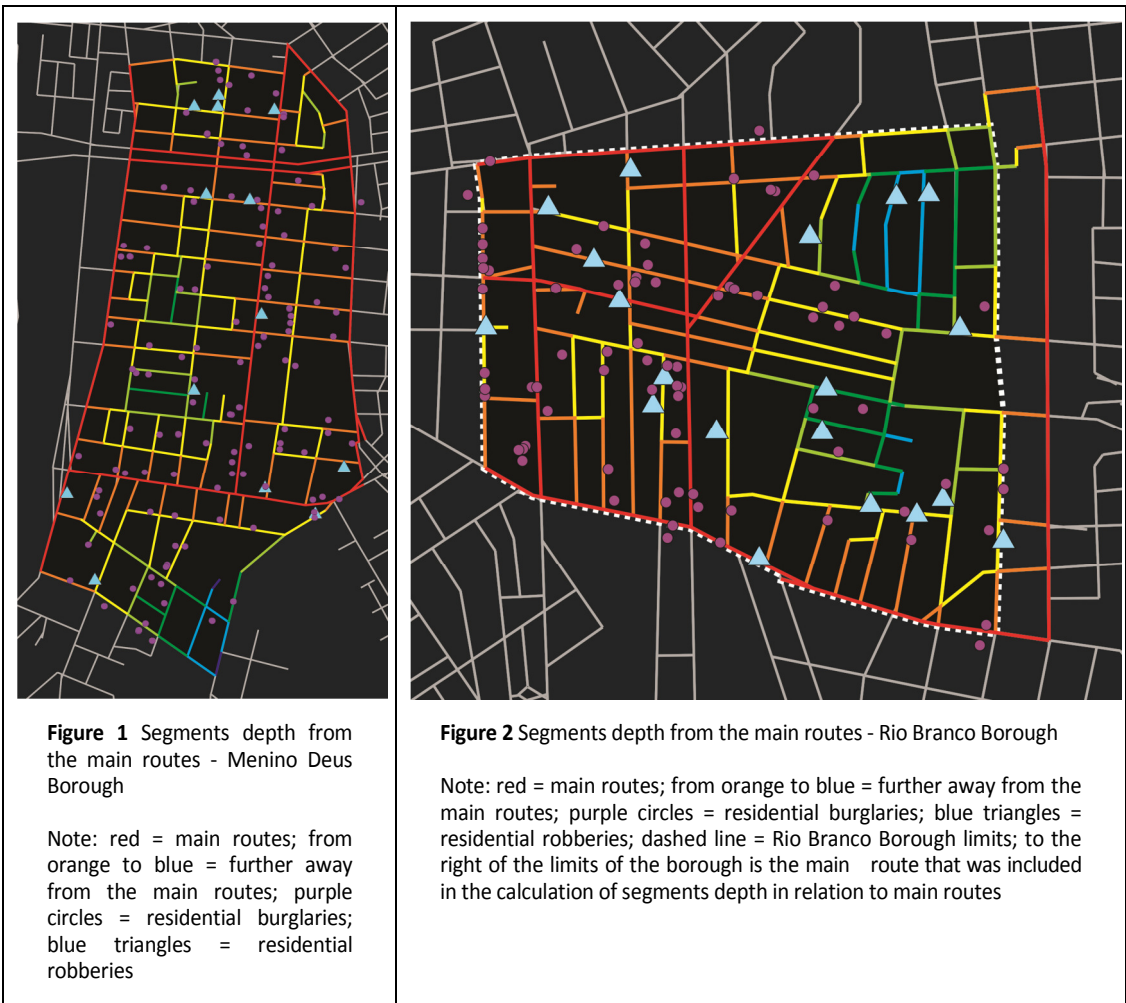
Relationship between the occurrence of robberies and burglaries and segment global and local choice

Either in general or for each of the two boroughs, no correlation between residential crime rate (residential robbery + residential burglary), either for each period of the day or the whole day, and global and local choice, was found, with the exception of a correlation between residential crime rate in the afternoon and segment local choice (Pearson, coef.=0,201, sig.=0,003) in Menino Deus Borough.   This suggests that homes in segments with higher local choice values are easier targets to residential crime in the afternoon than homes in segments with lower local choice values.   In general, no correlation between residential robbery rate (either for the whole day or for each period of the day) and segment global and local choice was found. In general, no correlation between residential burglary rate (for the whole day or for each period of the day) and segment global and local choice was found.   Either in general or for each of the two boroughs, no correlation between 'true risk rate for the bands' (considering residential

crime for the whole day) and segment global and local choice was found, with exception of a correlation (Pearson, coef.= 0,118, sig.=0,019) between 'true risk rate for the bands' and segment local choice when the 396 segments were considered.

Relationship between the occurrence of robberies and burglaries in homes and topological depth from the main routes

In general, in Menino Deus and in Rio Branco Borough, no correlations between residential crime rate (either for each period or for the whole day) and segment topological depth from the main routes were found.   In general, residential robbery rate (either for each period or for the whole day) was not found to correlate to segment topological depth from the main routes. In general, residential burglary rate (either for each period or for the whole day) was not found to correlate to segment topological depth from the main routes.   Although no correlation was found in Rio Branco, negative correlations between 'true risk rate for the bands' (considering residential crime for the whole day) and segment topological depth from the main routes were found in general (Pearson, coef.= -0,142, sig.=0,005) and in Menino Deus (Pearson, coef.= -0,190, sig.=0,005), suggesting that higher 'true risk rate for the bands' tends to happen in segments with lower depth from the main routes.

Figure 1 Segments depth from the main routes - Menino Deus Borough

Note: red = main routes; from orange to blue = further away from the main routes; purple circles = residential burglaries; blue triangles = residential robberies

Figure 2 Segments depth from the main routes - Rio Branco Borough

Note: red = main routes; from orange to blue = further away from the main routes; purple circles = residential burglaries; blue triangles = residential robberies; dashed line = Rio Branco Borough limits; to the right of the limits of the borough is the main   route that was included in the calculation of segments depth in relation to main routes

Relationship between the occurrence of robberies and burglaries and dwelling types (houses or buildings with three or more floors) and land use (residential or non-residential) in the segments

Considering the total sample, a negative correlation was found between residential crime rate (residential robbery + residential burglary) for the whole day and density of dwelling type 'house' (Pearson, coef.=-0,122, sig.=0,015), indicating a tendency for residential crime to decrease as the number of this dwelling type increases in a block. On the other hand, for the total sample, no correlation was found between residential crime rate for each period of the day and density of dwelling type 'house'.   Additionally, in general, no correlation was found between residential crime rate for the whole day and for each period of the day and density of dwelling type 'blocks of flats' (buildings with three or more floors).   In Menino Deus, residential crime rate (either for the whole day or for each period of the day) was not correlated either with density of houses or density of blocks of flats (buildings with three or more floors) in the segments.   In Rio Branco, residential crime rate (either for the whole day or for each period of the day) was not correlated either with density of houses or density of blocks of flats (buildings with three or more floors) in the segments.

In general, no correlation between residential robbery rate (either for the whole day or for each period of the day) and dwelling types (either houses or buildings with three or more floors) in the segments was found. Either in Menino Deus or in Rio Branco, no correlation between residential robbery rate for each period of the day and density of dwelling types (either 'house' or 'block of flats') was found, with exception of a correlation between residential robbery rate for the afternoon period and density of dwelling type 'block of flats' in Menino Deus borough (Pearson, coef.= 0,144, sig.= 0,033). This suggests that the higher the density of block of flats in a segment (number of access to blocks of flats divided by the length of the segment) the higher the possibility of a block becoming a target for robbery.

In the total sample, no correlation between residential burglary rate (for the whole day or for each period of the day) and density of dwelling types (either density of 'house' or density of 'blocks of flats') was found, with exception of a negative correlation (Pearson, coef.= -0,118*, sig.=0,019 between residential burglary rate for the whole day and density of dwelling type 'house'. In general, 'true risk rate for the bands' (considering residential crime for the whole day) was found to negatively correlate to density of dwelling type 'house' (Pearson, coef.= -0,290, sig. = 0,000) and to density of dwelling type 'block of flats' (Pearson, coef.= -0,216, sig.= 0,000).   In Menino Deus, 'true risk rate for the bands' (considering residential crime for the whole day) was also found to negatively correlate to density of dwelling type 'house' (Pearson, coef.= -0,322, sig.=0,000) and to density of dwelling type 'block of flats' (Pearson, coef.= -0,242, sig.=0,000). Additionally, in Rio Branco, 'true risk rate for the bands' (considering residential crime for the whole day) was found to negatively correlate to density of dwelling type 'house' (Pearson, coef.= -0,352, sig.=0,000) and to density of dwelling type 'block of flats' (Pearson, coef.= -0,197, sig.=0,009).

In general, density of residential units (number of accesses to residential units in the segment divided by segment length) was found to negatively correlate to residential crime rate for the whole day (Pearson, coef.= -0,142, sig.= 0,005) and to residential crime rate for the dawn period (Pearson, coef.= -0,115, sig.= 0,022). These results suggest that residential crime rate tends to decrease as the number of residential units increases in a block. On the other hand, in general, no correlation between residential crime rate (either for the whole day and or for each period of the day) and density of non residential units (number of accesses to non residential units in the segment divided by segment length) was found. In Menino Deus, residential crime rate for the whole day was negatively correlated to density of residential buildings (Pearson, coef.=

-0,164, sig.=0,015), and was not correlated to density of non residential buildings.   Looking at residential crime rate for each period of the day in Menino Deus, only a negative correlation (Pearson, coef.= -0,132, sig.=0,050) between residential crime rate in the dawn period and density of residential buildings was found. Considering these variables, no correlation was found in Rio Branco Borough.

Considering the total smaple, no correlation between residential robbery rate (either for the whole day or for each period of the day) and land use (either for density of residential units or for density of non-residential units) in the segments was found.   Therefore, land use as represented by density of residential units and density of non residential units did not appear to have an impact on residential robbery.

In general, the analysis of correlations between residential burglary rate (either for the whole day or for each period of the day) and land use (either for density of residential units or for density of non-residential units) in the segments only revealed a negative correlation between residential burglary rate for the whole day and density of residential units (Pearson, coef.= -0,135, sig.= 0,007) and a negative correlation between residential burglary rate for the dawn period and density of residential units (Pearson, coef.= - 0,108, sig.= 0,031). This result indicates that the higher the density of residential units in the segment the smaller the possibility of a burglary to happen, especially during the dawn period in that segment.

In total sample, 'true risk rate for the bands' (considering residential crime for the whole day) was negatively correlated to density of residential units (Pearson, coef.= -0,372, sig.= 0,000) and not correlated to non residential buildings. Additionally, in Menino Deus, 'true risk rate for the bands' (considering residential crime for the whole day) was negatively correlated to density of residential buildings (Pearson, coef.= -0,472, sig.= 0,000) and not correlated to non residential buildings.   Moreover, in Rio Branco, 'true risk rate for the bands' (considering residential crime for the whole day) was negatively correlated to density of residential buildings (Pearson, coef.= -0,303, sig. ,000) and not correlated to non residential buildings.

CONCLUSIONS

This research revealed, for the two residential boroughs in a large Brazilian city, that residential burglary is much more frequent than is residential robbery. Also, both types of crime clearly decreased during the night period (from 6 p.m. to midnight), probably because residents are in their homes and there is much more movement of people in the streets compared to the dawn period. Residential crime tend to increase during the summer vacations months (January and February) and to decrease in winter months (June and July), what might be explained by the fact that burglaries, which happen in vacant homes, respond for most of residential crimes.   There is also a clear tendency for residential burglary to decrease on Sundays.

No correlation was found between residential crime rate (and specifically, residential robbery rate and residential burglary rate) and segment length.   On the other hand, it was found some effect of segment length on 'true risk rate for the bands', with lengthier segments being safer.

Segment connectivity was found to have only a small effect on residential robbery, with homes in less connected segments becoming easier targets to robbery in the morning than homes in more connected segments, what is not coincident with the following: 'It was next shown that lower segment connectivity was associated prima facie with lower rates of burglary, confirming the result of Johnson and Bowers (2009), though with the peak at five- rather than six-connected segments' (Hillier and Sahbaz 2012, p.135). However, they emphasized that '...segment connectivity does not, as commonly believed, predict movement.' (Hillier and

Sahbaz 2012, p.135).

Regarding the effects integration, only a weak effect of segment global integration on residential burglary was found, the higher the global integration value of a segment the higher the possibility of a residence in such segment being burglarized in the morning. Global and local integration were found to have some impact on 'true risk rate for the bands', with higher values of integration indicating higher 'true risk rate for the bands'. Therefore, these results are not in accordance with those obtained by some studies, as follows:

> 'Houses located in those globally integrated areas, which are highly accessible, tend to be less vulnerable than those situated in globally segregated areas, which is also true in most case studies.' (Shu 2009, p.14)

> 'In the two cities that were studied, locally segregated street segments apparently carried a higher burglary risk than the locally integrated ones.' (Van Nes and López 2010, p.310).

Nonetheless, according to results obtained by Hillier and Sahbaz (2012, p.134), it would be necessary to consider the number of dwellings on the segment in order to verify the effect of integration on residential burglary, as follows: '… with more than about 25 dwellings on the segment, higher spatial integration, and thus more movement potential, was associated with lower rates of burglary, while with less than 25 dwelling higher integration was associated with higher rates of burglary.' Regarding choice values, it was only found that homes in segments with higher local choice values (therefore, segments that are part of more preferred routes) are easier targets to residential crime in the afternoon than homes in segments with lower local choice values. Segments with higher local choice values slightly indicated higher 'true risk rate for the bands'.

Segment topological depth from the main route was not found to have an impact on residential crime rate (and specifically, on residential robbery rate and residential burglary rate). On the other hand, higher 'true risk rate for the bands' tended to happen in segments with lower depth from the main routes. Hence, these results are not supported by the study carried out by Van Nes and López (2010, p.309) where 'Apparently, chances of residential burglary increased the further away one was from the main routes through urban areas.'

A slight tendency for residential crime rate to decrease as density of dwelling type 'house' increases in a segment was found. No effect of density of dwelling type 'block of flats' on residential crime was found. A minor tendency was found for higher densities of block of flats in a segment to increase the possibility of a home becoming a target for robbery. On the other hand, it was found a slight tendency for higher densities of houses in a segment to indicate a smaller possibility of a home becoming a target for burglary. Density of dwelling type 'house' and density of dwelling type 'block of flats' in a segment were found to have an effect on 'true risk rate for the bands', higher densities of houses and higher densities of block of flats indicating lower 'true risk rate for the bands', what is supported by Hillier and Sahbaz (2012, p134) findings:

> '…it was shown that in all parts of the borough, ground-level residential density, … was associated with substantially lower levels of burglary both for single houses and buildings with multiple dwellings. Off-the-ground density was also associated with lower levels of burglary, but less so and less clearly than ground-level density.' (Hillier and Sahbaz 2012, p. 134).

Regarding land use, higher density of residential accesses in a segment tended to provoke a decrease in residential crime rate, specifically in the dawn period. No effect of density of

non residential accesses on residential crime was found. Although no effect of land use on residential robbery rate was found, residential burglary rate in the dawn period had some tendency to decrease as density of residential accesses increased. Higher densities of residential accesses tended to indicate lower 'true risk rate for the bands', whereas no effect of densities of non residential accesses was found. Hence, these results are supported by studies carried out by Hillier and Sahbaz (2012, p.134,135), where:

'··· higher numbers of dwellings on the street segment reduced the risk or burglary';

'By far, the most important [finding] is that higher residential populations linked to spaces – that is, to street segments – are pervasively associated with lower rates of … residential burglary …';

'···it [numbers of dwellings] may be the most important single variable in the relationship between crime and space in cities.'

Although it is necessary to further test the relationship of the variables considered in this study, the sample sizes considered for the two boroughs might have had some impact on the results produced by this research. Nonetheless, some contribution to the existing knowledge may be added, for example, by identifying the temporal distribution of residential crime and relating such distribution during the day to the variables considered in the study.

REFERENCES

Clarke, R. V. G. 1992. *Situational crime prevention: successful case studies*. New York: Harrow and Heston Publishers.

Jacobs, Jane. 1961. *The death and life of great American cities*. New York: Random House.

Hillier, B., and S. Shu. 2000. "Crime and urban layout: the need for evidence." In *Secure Foundations. Key issues in crime prevention, crime reduction and community safety*, edited by S. Ballintyne, K. Pease, and V. McLaren. Institute for Public Policy research, London.

Hillier, B., and S. Iida. 2005. "Network and psychological effects in urban movement." In *Proceedings of Spatial Information Theory: International Conference,* edited by A.G. Cohn, and D.M. Mark. Ellicottsville, N.Y., U.S.A. pp. 475-490.

Hillier, B., and O. Sahbaz. 2005. "High Resolution Analysis of Crime Patterns in Urban Street Networks: an Initial Statistical Sketch from an Ongoing Study of a London Borough." In *Proceeding of the 5th International Space Syntax Symposium*, edited by A. van Nes. Delft, Netherlands. pp. 451-478.

Hillier, Bill. 2007. "Using DepthMap for urban analysis: a simple guide on what to do once you have an analysable map in the system." MSc Advanced Architectural Studies, 2007-8. UCL, London.

Hillier, B., and Ozlem Sahbaz. 2012. ''Safety in numbers: high resolution analysis of crime patterns in urban street networks.'' In *Urban Fabric of Crime and Fear*, edited by V. Ceccato. Springer.

Newman, Oscar. 1972. *Defensible space; crime prevention through urban design*. New York: Macmillan.

Poyner, Barry, and Barry Webb. 1991. *Crime free housing*. Oxford: Butterworth-Architecture.

Shu, C. 2009. "Spatial Configuration of Residential Area and Vulnerability of Burglary Case Studies from UK and Taiwan." In *Proceeding of the 7th International Space Syntax Symposium,* edited by D. Koch, L. Marcus, and J. Steen. Stockholm, Sweden. : 102:1-102:15.

Van Nes, A., and M. J. J. López. 2007. "Micro Scale Spatial Relationships in Urban Studies: the relationship between private and public space and its impact on street life." In *Proceeding of the 6th International Space Syntax Symposium,* Istanbul. : 023-01 – 023-12.

Van Nes, A., and M. J. J. López. 2010. "Macro and Micro Scale Spatial Variables and the Distribution of residential Burglaries and Theft from Cars: An investigation of space and crime in Dutch cities of Alkmaar and Gouda." *The Journal of Space Syntax* 1(2): 296-314.

Voordt, D., and H. Wegen. 1993. "The Delft Checklist on Safe Neighborhoods." *Journal of Architectural and Planning Research* 10(5): 341-356.