

## #106

### PEDESTRIAN MUGGING IN DIFFERENT PERIODS OF THE DAY AND SEGMENTS ATTRIBUTES IN MOST CENTRAL BOROUGHES OF PORTO ALEGRE

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#### ABSTRACT

This paper investigates the occurrence of pedestrian mugging in different periods of the day (morning, afternoon, night and dawn) and their relationship with physical-spatial attributes of segments in 22 most central boroughs of Porto Alegre, including: segment length, connectivity, integration and choice, physical and visual connections, physical and visual barriers, lampposts, number of garage doors, types of building uses, and the uses during each of the four periods of the day on ground floors. In addition to the period of the day, other temporal attributes are considered, such as day of week, month and year in which the pedestrian mugging occurred. The 22 boroughs in the most central area of Porto Alegre were selected due to the highest concentration of crime in the streets, and to the fact that they are the most consolidated and dense urban areas, enabling the identification of the physical-spatial attributes of the segments. The pedestrian mugging occurrences were collected through digital platform “Where I was robbed” ([www.ondefuirobado.com.br](http://www.ondefuirobado.com.br)) and cover the period from 01/01/12 to 31/03/16, totalizing 4 years and 3 months. The information obtained was recorded in the Quantum GIS program, based on a satellite image of the region and related to a segment map, generated by Depthmap. Segments attributes such as segment length, connectivity, integration and global and local choice were quantified by segments map analysis in Depthmap for the whole region covered by the 22 boroughs. The following segments attributes were identified and quantified via Google Street View for 30 segments with no pedestrian mugging in any of the four periods of the day and for 10 segments with most pedestrian mugging in each period (28 different segments since 12 segments were selected for more than one period): functional connections (number of accesses); visual connections, physical and visual barriers, lampposts; and garage doors. Types of building uses (residential, commerce/services and mixed use), and the uses during each of the four periods of the day on ground floors (the existence or not of residential, services or commercial activities) were identified through a map of uses elaborated by the City Council and checked via Google Street View. In addition, statistical analyses were performed in SPSS/PC program. The results show, for example, the tendency of pedestrian mugging to occur in the segments with lower visual and physical permeability and with greater length. Moreover, pedestrian mugging occurs with greater intensity in the Centro Borough and its immediate vicinity, mainly during the night, followed by the afternoon period.

## KEYWORDS

Pedestrian mugging, segments attributes, street crime

## 1. INTRODUCTION

The importance of physical variables in preventing or reducing the possibilities of crime, including pedestrian mugging, has been established in studies carried out in distinct cities of different countries (Poyner and Webb, 1991; Voordt and Wegen, 1993; Hillier and Shu, 2000; Hillier and Sahbaz, 2005; Shu, 2009; van Nes and López, 2010; Hillier and Sahbaz, 2012). However, this is a complex subject where many physical variables are involved and interrelated, apart from other aspects, such as social, economic, and political ones, that may influence the occurrence of crime (Caldeira, 2000; Zaluar, 2002).

Although the relationship between physical variables (such as global and local integration) and the occurrence of crime has been dealt with by some studies, no conclusive evidence seems to have been produced. In this respect, it has been mentioned the scarcity of spatial analysis researches that focus on street robbery (Chiaradia et al., 2009). Moreover, different approaches regarding types of crimes and periods of the day when crime occurs have been considered in distinct studies, with some making a distinction between periods of crime occurrence and types of variables involved (i.e., Monteiro and Iannicelli, 2009). Additionally, it is not clear, for example, what is an acceptable level of physical and visual connections between the buildings and the street in order to make the streets safer.

It follows that there is a need to deepen the knowledge about the relationship between pedestrian mugging in different periods of the day and segments attributes. Therefore, this paper investigates the occurrence of pedestrian mugging in different periods of the day (morning, afternoon, night and dawn) and their relationship with physical-spatial attributes of segments in 22 most central boroughs of Porto Alegre, including: segment length, connectivity, integration and choice, physical and visual connections, physical and visual barriers, lampposts, number of garage doors, types of building uses, and the uses during each of the four periods of the day on ground floors. In addition to the period of the day, other temporal attributes are considered, such as day of week, month and year in which the pedestrian mugging occurred.

## 2. DATASETS AND METHODS

The 22 boroughs in the most central area of Porto Alegre (Figure 1) were selected due to the highest concentration of crime in the streets, and to the fact that they are the most consolidated and dense urban areas, enabling the identification of the physical-spatial attributes of the segments.



Figure 1. Selected boroughs (22) in Porto Alegre

Note: 1 = Centro Histórico (Historic Center); 2 = Bom Fim; 3 = Cidade Baixa; 4 = Farroupilha; 5 = Santana; 6 = Azenha; 7 = Menino Deus; 8 = Praia de Belas; 9 = Floresta; 10 = Independência; 11 = Moinhos de Vento; 12 = Rio Branco; 13 = Jardim Botânico; 14 = Petrópolis; 15 = Bela Vista; 16 = Três Figueiras; 17 = Chácara das Pedras; 18 = Boa Vista; 19 = Higienópolis; 20 = Auxiliadora; 21 = Mont'Serrat; 22 = Santa Cecília.

Data regarding pedestrian mugging occurrences were collected from 01/01/12 to 31/03/16, totaling 4 years and 3 months, through the digital platform "Where I was robbed" ([www.ondefuirobado.com.br](http://www.ondefuirobado.com.br)) which is an app that allows the victim to mark on a city map the exact spot/address (street name and the closest building number) where the mugging occurred and fill in details like time, date, stolen items and a small description of the mugging. Therefore, it was necessary to be aware of the existence of the platform and to have access to the internet in order to register such crime, which might have had some effect on the victim type that registered the occurrence, for example, favoring such registration by students and workers of the Federal University of Rio Grande do Sul (UFRGS) that is located nearby many segments with most pedestrian mugging. Then, to avoid distortion (for example, in having segments from regions not used by students), the selection of segments with no pedestrian mugging was made considering a maximum distance of three steps of depth from a segment with most pedestrian mugging. The information obtained was recorded in the Quantum GIS program, based on a satellite image of the region and related to a segment map, generated by Depthmap. Segments' attributes such as segment length, connectivity, global (Figure 2) and local integration and global and local choice were quantified by segments map analysis in Depthmap for the whole region covered by the 22 boroughs.





Figure 2 - Global integration Rn

The following attributes were identified and quantified via Google Street View for 30 segments with no pedestrian mugging in any of the four periods of the day (Figure 3) and for 10 segments with most pedestrian mugging (varying from 2 to 10 mugging in a segment) in each period (Figures 4, 5, 6 and 7; 28 different segments, since 12 segments were selected for more than one period) in a total of 58 segments: functional connections (number of accesses); visual connections, physical and visual barriers, lampposts, and garage doors. Types of building uses (residential, commerce/services and mixed use), and the uses during each of the four periods of the day on ground floors (the existence or not of residential, services or commercial activity) were identified through a map of uses elaborated by the City Council and checked via Google Street View.



Figure 3. 30 segments with no pedestrian mugging in any of the four periods of the day

Note: 1 = Centro Histórico (Historic Center); 2 = Praia de Belas; 3 = Cidade Baixa; 4 = Santana; 5 = Farroupilha; 6 = Rio Branco; 7 = Bom Fim; 8 = Independência; 9 = Floresta; white lines represent boroughs' boundaries.





Figure 4 - 10 segments with most pedestrian mugging in the morning period

Note: orange dots = pedestrian mugging in the morning period.



Figure 5 - 10 segments with most pedestrian mugging in the afternoon period

Note: green dots = pedestrian mugging in the afternoon period.





Figure 6 - 10 segments with most pedestrian mugging in the night period

Note: pink dots = pedestrian mugging in the night period.



Figure 7 - 10 segments with most pedestrian mugging in the dawn period

Note: blue dots = pedestrian mugging in the dawn period..

To enable comparison between segments, a rate was calculated for each attribute. Physical connection rates were obtained by dividing the total number of physical connections (doors that allow a person to access a building from the street) in both sides of the street segment (i.e. 58 accesses) by the double of the segment length (i.e.  $274.11 \text{ m} \times 2 = 548.22 \text{ m}$ ), which, in this example, results in a physical connection rate of 0.106. This means that there is access to a building every 9.45 meters in the total length of both sides of this segment ( $548.22 \text{ m} / 58$  accesses). Visual connection rates were calculated by dividing the total length (in meters) of visual connections (windows and glass doors that allow a person inside the building to look at the street) in both sides of the street (i.e. 71 m) by the double of the segment length (i.e.  $274.11 \text{ m} \times 2 = 548.22 \text{ m}$ ), which, in this example, results in a visual connection rate of 0.130. This means that only 13% of the total of 548.22 m are visually connected to the public open spaces of streets. Physical and visual barriers (such as walls) rates were generated by dividing the extent (in meters) of such barriers in both sides of the segment by twice the segment length. Lampposts rates were generated by dividing the number of lampposts in both sides of the segments by the segment length. Garage doors rates were calculated dividing the extent of such doors (in meters) in both sides of the segment by the double of the segment length. Rates of residential, commercial/services and mixed use buildings were generated dividing the number of each of these buildings types in both sides of the segment by twice the segment length. Rates of residential, services and commercial activities on ground floor of buildings facing the streets were calculated by dividing the quantity of each of these types of activities on both sides of the street segment by double of the segment length. Therefore, with exception of lampposts rate, which is an attribute of the segment and not of each of its sides or interfaces, variables rates are divided by double of the segment length because the attributes considered belong to each of the two segment sides, more precisely reflecting the relationship between the characteristics of the two segment interfaces and the length of these interfaces. In addition, statistical analyzes were performed in SPSS/PC program, correlating (Spearman correlation test) pedestrian muggings in each of four periods of the day with segments attributes.

### 3. RESULTS

Most pedestrian mugging in the 28 selected segments, from 2012 to 2016, tends to occur during the night period (55) followed by the afternoon (43), the dawn (25) and the morning (24) period, which emerges as the safest period to walk on the streets (Figure 8). Regarding day of the week, most pedestrian mugging occurred on Wednesdays (26), closely followed by Saturdays (25), Thursdays (24) and Fridays (23). The day with the smallest number of pedestrian mugging occurrences is Sunday (13), followed by Monday (18) and Tuesday (18). The largest amount of pedestrian mugging occurred on September (19) and in June (18) and the least amount occurred in December (8), followed by January (9), February (10), and May, October and November (11).

The percentage of segments with length above 150m is clearly greater in the segments with most pedestrian mugging (varying from 40% in the night to 60% in the afternoon and in the dawn period), regardless of the period of the day, than in the segments with no pedestrian mugging in any period of the day (13.33%). Regarding segment connectivity, values do not reveal any major differences either between periods of the day for the segments with most pedestrian mugging or for the segments with no pedestrian mugging in any period of the day.





Figure 8 - Pedestrian mugging in each of the four periods of the day

Note: coloured dots represent pedestrian mugging in the four periods of the day, as follows: orange = morning, green = afternoon, pink = night, blue = pedestrian mugging in the dawn period..

Considering the global integration values of all 30 segments without pedestrian mugging in any period of the day and of all segments with most pedestrian mugging in any of the four periods of the day (10 segments in each period in a total of 28, since 12 of these segments are repeated in different periods of the day), it is revealed that: the percentage of segments with the highest values is much smaller in the segments with no pedestrian mugging in any period of the day (20%) than in the segments with most pedestrian mugging in the morning (50%), in the afternoon (40%), and in the night (60%), disregarding the dawn period since integration values are not really useful during dawn, when differences in movement of people and vehicles during the other three periods tend to significantly diminish or to disappear. Moreover, 30% of the 30 segments with no pedestrian mugging have the lowest global integration values, while no segment with most pedestrian mugging in the morning, afternoon and in the night is in this group. Therefore, pedestrian mugging tends to occur in the segments with higher global integration values, as also evidenced by the highest and lowest global integration values and by the mean of global integration values of all segments in each of the five groups of segments (Table 1).

	Segments with no pedestrian mugging (30)	Segments with most pedestrian mugging in the morning (10)	Segments with most pedestrian mugging in the afternoon (10)	Segments with most pedestrian mugging in the night (10)	Segments with most pedestrian mugging in the dawn (10)
Global integration $R_n$ (varying from 3714.87 to 4979.00 in a group of 58 different segments)					
Highest values (4557.01 – 4979.00)	6 (20%)	5 (50%)	4 (40%)	6 (60%)	3 (30%)
Medium values (4136.01 – 4557.00)	15 (50%)	5 (50%)	6 (60%)	4 (40%)	6 (60%)
Lowest values (3714.00 – 4136.00)	9 (30%)	0 (0%)	0 (0%)	0 (0%)	1 (10%)
Local integration $R_{750}$ (varying from 58.99 to 1062.04 in a group of 58 different segments)					
Highest values (728.01 – 1063.00)	2 (6.67%)	0 (0%)	3 (30%)	3 (30%)	1 (10%)
Medium values (394.01 – 728.00)	5 (16.67%)	3 (30%)	3 (30%)	2 (20%)	0 (0%)
Lowest values (58.00 – 394.00)	23 (76.67%)	7 (70%)	4 (40%)	5 (50%)	9 (90%)

Note: there are 58 different segments (and not 70) because 12 segments are among those with most pedestrian mugging in more than one period of the day.

Table 1 - Global e local integration



Regarding local integration, most segments with no pedestrian mugging (76,76%) and with pedestrian mugging in the morning (70%) have the lowest values, also evidenced by the mean of local integration values of all segments in each of these two groups of segments (Table 1). Hence, there is no clear indication about the effect of local integration values on the occurrence of pedestrian mugging, what is also shown by the local integration values in the segments with most pedestrian mugging in the periods of afternoon and night.

	Segments with no pedestrian mugging (30)	Segments with most pedestrian mugging in the morning (10)	Segments with most pedestrian mugging in the afternoon (10)	Segments with most pedestrian mugging in the night (10)	Segments with most pedestrian mugging in the dawn (10)
Global choice $R_n$ (varying from 12.00 to 41425612.00 in a group of 58 different segments)					
Highest values (27617078.01 - 41425612.00)	0 (0%)	4 (40%)	3 (30%)	3 (30%)	1 (10%)
Medium values (13808545.01 - 27617078.00)	2 (6.67%)	0 (0%)	0 (0%)	1 (10%)	0 (0%)
Lowest values (12.00 - 13808545.00)	28 (93.33%)	6 (60%)	7 (70%)	6 (60%)	9 (90%)
Local choice $R_{750}$ (varying from 23.00 to 115357.00 in a group of 58 different segments)					
Highest values (76912.01 - 115357.00)	0 (0%)	0 (0%)	1 (10%)	1 (10%)	1 (10%)
Medium values (38467.01 - 76912.00)	1 (3.33%)	0 (0%)	0 (0%)	1 (10%)	0 (0%)
Lowest values (23.00 - 38467.00)	29 (96.67%)	10 (100%)	9 (90%)	8 (80%)	9 (90%)

Table 2 - Global e local choice

Global choice analysis shows that almost the totality of segments with no pedestrian mugging (93.33%) has the lowest values (Table 2). However, the majority of segments with most pedestrian mugging in the morning (60%), in the afternoon (70%) and in the night (60%) also have the lowest global choice values. The dawn period has been disregarded since route choice values are not really useful during dawn, when differences in movement of people and vehicles during the other three periods tend to significantly diminish or to disappear. Hence, there are no clear indications about the effect of global choice on pedestrian mugging. Local choice analysis reveals that the totality or the clear majority of segments, either with or without pedestrian mugging have the lowest local choice values (Table 2). Nonetheless, pedestrian mugging in the afternoon was found to rise as local choice increased, as revealed by the positive correlation (Spearman correlation, coef. = .392, sig. = .032) between these two variables. Physical connections rates analysis reveals that while 56.67% of segments with no pedestrian mugging have high or very high physical connections rates, the totality of segments with most pedestrian mugging in the morning and in the afternoon, and 90% of the segments with most pedestrian mugging in the night have low or very low physical connections rates, disregarding the dawn period due to inexistent or almost inexistent access to buildings from the streets (Table 3). Therefore, in any of the three periods of the day, pedestrian mugging fundamentally occurs in segments with a physical connection rate not greater than 0.077 (means an access to a building every 13 meters or more, in case they were evenly distributed), and the majority of this type of crime occurs in segments with physical connection rates not greater than 0.038 (means an access to a building every 26 meters or more, in case they were evenly distributed), in any of the three periods of the day considered (Table 3). It follows that the number of physical connections between the buildings and the street in a segment is a strong indicator of pedestrian mugging in such segment. Nonetheless, although these data reveals the number of access to buildings in the segments, they do not reveal the location of such accesses, if they are close together, equally distributed in both sides of the street, or else, what is not part of the objectives of this research.

	Segments with no pedestrian mugging (30)	Segments with most pedestrian mugging in the morning (10)	Segments with most pedestrian mugging in the afternoon (10)	Segments with most pedestrian mugging in the night (10)	Segments with most pedestrian mugging in the dawn (10)
Physical connection rates (varying from 0.000 to 0.193 in a group of 58 different segments)					
Very high rates (0.155–0.193)	6 (20%)	0 (0%)	0 (0%)	0 (0%)	1 (10%)
High rates (0.116–0.154)	11 (36.67%)	0 (0%)	0 (0%)	1 (10%)	3 (30%)
Medium rates (0.078–0.115)	7 (23.33%)	0 (0%)	0 (0%)	0 (0%)	4 (40%)
Low rates (0.039–0.077)	6 (20%)	2 (20%)	2 (20%)	3 (30%)	0 (0%)
Very low rates (0.000–0.038)	0 (0%)	8 (80%)	8 (80%)	6 (60%)	2 (20%)
Visual connection rates (varying from 0.000 to 0.486 in a group of 58 different segments)					
Very high rates (0.389–0.486)	1 (3.33%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
High rates (0.292–0.388)	3 (10%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Medium rates (0.195–0.291)	9 (30%)	0 (0%)	0 (0%)	0 (0%)	1 (10%)
Low rates (0.098–0.194)	12 (40%)	1 (10%)	0 (0%)	1 (10%)	6 (60%)
Very low rates (0.000–0.097)	5 (16.67%)	9 (90%)	10 (100%)	9 (90%)	3 (30%)

Note: a physical connection rate of 0.193 means that there is access to a building every 5.17 meters (289.62m / 56 access) in the total length of both sides of this segment (289.62m) ; a visual connection rate of 0.486 means that 49% of the total length of both sides of some segment presents a visual connection between the buildings and the public open space of a street.

Table 3 - Physical and visual connection rates

Although the majority (56.67%) of segments with no pedestrian mugging have low or very low visual connections rates (Table 3) between the buildings and the streets, the totality of segments with pedestrian mugging in the morning, in the afternoon and in the night have low or very low visual connection rates, disregarding the dawn period due to inexistent or almost inexistent visual supervision of streets by people inside the buildings. Therefore, pedestrian mugging occurs in segments where no more than 19% (rate of 0.194) of their total length (both sides of the street defined by the segment) is visually connected. Moreover, the totality of pedestrian mugging in the afternoon, and almost the totality (90%) in the morning and in the night occurred in segments where the visual connections between the buildings and the street is not greater than 10% (rate of 0.097) of the total segment length (both sides). Therefore, visual connection rates emerge as an important indicator of pedestrian mugging during the morning, afternoon and night periods. Moreover, pedestrian mugging in the afternoon period was found to be negatively correlated with visual connection rates (Spearman correlation, coef. = -.426, sig. = .019) confirming that pedestrian mugging increases as these rates decrease. Nonetheless, these results do not inform the location and distribution of the visual connections along both sides of the segment, which is not the objective of this research.

Garage door rates analysis shows that the number of garage doors in a segment did not emerge as a facilitator of pedestrian mugging, in any of the three periods considered. The totality of pedestrian mugging during the night and almost the totality during the dawn period (80%) occurred in the segments with low (0.044 – 0.069) or very low (0.017 – 0.043) lamppost rates, and no pedestrian mugging in the dawn period occurred in the segments with very high or high lamppost rates. Hence, these findings reveal the importance of well-lit streets in order to prevent or diminish the occurrence of crime in public open spaces during periods without natural light. The totality of segments with most pedestrian mugging in the morning, and almost the totality of those segments with most pedestrian mugging in the afternoon (90%) and in the night (80%) have very low rates of physical and visual barriers (0.000 – 0.100). Therefore, physical and visual

barriers (such as walls) in the streets are not found to be specific facilitators of pedestrian mugging in these three periods of the day, disregarding the dawn period when these barriers does not play a role in blocking the visual supervision of the streets from the buildings.

Mixed use building rates analysis reveals that the clear majority of segments with most pedestrian mugging in the morning (80%), in the afternoon (80%) and in the night (70%) have very low mixed use building rates (0.000 – 0.009). Additionally, pedestrian mugging did not occur in segments with very high rates (0.037 – 0.046) and almost did not occur in segments with high rates (0.028 – 0.036) of mixed use buildings in any of the three periods of the day. On the other hand, 43.34% of the segments with no pedestrian mugging have very high or high rates of mixed use buildings while only 16.6% of these segments have very low mixed use building rates (0.000 – 0.009). Consequently, the existence of mixed use buildings in a street tend to have a positive effect in reducing pedestrian mugging, what is also evidenced by the clearly higher total mean rate (0.025) in the segments with no pedestrian mugging than in the segments with most pedestrian mugging in different periods of the day. The analysis of residential use buildings shows that all segments with most pedestrian mugging in the morning and in the afternoon and 90% of segments with most pedestrian mugging in the night have very low rates (0.000 – 0.020) of residential use buildings, while 53.33% of segments with no pedestrian mugging have the same rates. Therefore, pedestrian mugging in these periods of the day is made easier in streets with very low rates of residential use buildings. This is supported by the fact that pedestrian mugging in the morning and in the afternoon were found to increase as the rate of residential use buildings decreased, according to the negative correlation (respectively: Spearman correlation, coef. = -.422, sig. = .020; Spearman correlation, coef. = -.493, sig. = .006) between pedestrian mugging in each of this two periods and rate of residential use buildings.

Regarding the existence of buildings with commercial/services use in the segment, 80% of pedestrian mugging in the morning, 100% in the afternoon, and 70% in the night period occurred in segments with very low rates (0.000 – 0.016) of buildings with commercial/services use. Therefore, the occurrence of pedestrian mugging tends to concentrate in the streets segments where rates of buildings with commercial/services use are very low, that is, where there is an access to a building with commercial/services use every 62.5m or more. Considering the existence of residential activities on ground floors facing the streets, it is revealed that 100% of segments with most pedestrian mugging in each of the four periods of the day, have low rates of ground floor residential activities (0.000 – 0.023), which means an access to a ground floor with residential activity every 43.5m or more. As a result, the existence of residential activities on ground floors of buildings facing the streets each 43m or less in average tends to discourage the occurrence of pedestrian mugging. This is corroborated by the negative correlation (Spearman correlation, coef. = -.617, sig. = .000) between pedestrian mugging in the afternoon and the rate of residential activities at ground floor during afternoon.

Concerning the existence of service activities on ground floor of buildings facing the streets, 100% of the segments with most pedestrian mugging in any period of the day have low rates (0.00 – 0.010) of service activities on ground floors, which means an access to a ground floor with service activity every 100 m or more. Therefore, the existence of some service activities on ground floors of buildings in a mean distance smaller than a 100m in a certain street tends to reduce the occurrence of pedestrian mugging. This is supported by the negative correlation (Spearman correlation, coef. = -.427, sig. = .019) between pedestrian mugging in the afternoon and the rate of service activities at ground floor during afternoon. On the other hand, pedestrian mugging in the night was found to be positively correlated (Spearman correlation, coef. = .447, sig. = .013) with rate of service activities at ground floor during the night.

The analysis carried out on the existence of commercial activities on ground floors of buildings facing the streets reveals that 100% of the segments with most pedestrian mugging in any period of the day have low rates (0.000 – 0.041) of commercial activities on ground floors, which means an access to a ground floor with commercial activity every 24.4 m or more. Hence, the existence of commercial activities on ground floors of buildings facing the streets each 24m or less in average tends to discourage the occurrence of pedestrian mugging.



#### 4. CONCLUSIONS

The most dangerous time period for pedestrian mugging is the night, followed by the afternoon, while the morning is the least dangerous to walk on the streets considered in this study. Wednesday, closely followed by Saturday, Thursday and Friday were found to be the most unsafe days, while Sunday was found to be least unsafe, followed by Monday and Tuesday. September, closely followed by June, were found to be the most risky months, while December, followed by January, February, May, October and November were found to be the least risky months to walk on the streets, what suggest a tendency for warmer months, when there is more people walking on the streets, to be less unsafe.

The tendency for pedestrian mugging to be more intense in longer segments has been confirmed in this study, mainly in segments longer than 150m. On the other hand, segment connectivity was not found to have an impact on pedestrian mugging and so, is in line with the fact that '...segment connectivity does not, as commonly believed, predict movement.' (Hillier and Sahbaz 2012, p.135). Contrary to some studies, where houses located in globally integrated areas tended to be less vulnerable than those situated in globally segregated areas (Shu, 2009), pedestrian mugging tends to occur in the segments with higher global integration values, what is supported by higher numbers of pedestrian mugging during the night in segments with higher global integration values (Reis et al, 2015). Regarding local integration and global choice values, no clear effect on the occurrence of pedestrian mugging was found, differently from other study (Reis et al, 2015) where higher local integration values were related to a decrease in pedestrian mugging during the night and global choice was the only variable to be related to a reduction in pedestrian mugging during the morning. The fact that segments with most pedestrian mugging tend to have the lowest local choice values may reveal the effect of this variable, although segments with no pedestrian mugging also tend to have the lowest values. Nonetheless, pedestrian mugging in the afternoon was found to rise with the increase of local choice values. Additionally, other research findings (Reis et al, 2015) revealed that higher local choice values were related to an increase in pedestrian mugging during the night period.

The number of physical connections between the buildings and the street in a segment is a strong indicator of pedestrian mugging in such segment (in the morning, afternoon and in the night period), and accesses to buildings should exist, if equally distributed in both sides of a street segment, at distances less than 13 meters in order to minimize the occurrence of pedestrian mugging. This is supported by other results where a reduction in pedestrian mugging during the night was related to an increase in the rate of physical connections in a segment (Reis et al, 2015). Visual connection between the buildings and the streets was also found to be an important indicator of pedestrian mugging during the morning, afternoon and night periods, indicating that this type of crime tends to be reduced when more than 19% of the total length of both sides of the street segment is visually connected. The number of garage doors and existence of physical and visual barriers (such as walls) in a street segment were not found to be specific facilitators of pedestrian mugging in the three periods of the day, with an exception that pedestrian mugging tend to rise in the morning period as physical and visual barriers increase. On the other hand, decrease in pedestrian mugging during the night and the dawn period is related to a better lit street, showing that a lamppost at distances smaller than 14.5m in a street segment is likely to contribute to reduce pedestrian mugging. This result is supported by the positive effect of poles with street lighting on reducing pedestrian mugging during the dawn, in another investigation (Reis et al, 2015).

The existence of mixed use buildings in a street segment tend to have a positive effect in reducing pedestrian mugging, in any of the three periods of the day, with a mean distance equal or smaller than 59m between such buildings, in both sides of a segment, having a tendency to decrease the occurrence of pedestrian mugging. Pedestrian mugging in the morning, afternoon and in the night is made easier in street segments with very low rates of residential use buildings, which means that a residential building at mean distances smaller than 50m in the total segment length is likely to favour a reduction in this type of street crime. This is supported by a decrease of pedestrian mugging in the morning and in the afternoon as the rate of residential use buildings increases. Moreover, an access to a building with commercial/

services use at a mean distance smaller than 62.5m has a tendency to reduce the occurrence of pedestrian mugging. The existence of residential activities on ground floors of buildings facing the streets each 43m or less in average tends to discourage the occurrence of pedestrian mugging. This is corroborated by a decrease in pedestrian mugging in the afternoon as the rate of residential activities at ground floor during afternoon increases.

Additionally, the existence of service activities on ground floors in a mean distance smaller than a 100m was found to reduce the occurrence of pedestrian mugging. This is supported by a decrease in pedestrian mugging in the afternoon as the rate of service activities at ground floor during afternoon increases. Nonetheless, pedestrian mugging in the night was found to increase with an increase in the rate of service activities at ground floor during the night. This may happen due to the fact that service activities during the night are not enough to generate intense presence of people and so, users are not protected by the co-presence in these street segments. Moreover, the existence of commercial activities on ground floors of buildings facing the streets each 24m or less in average tends to discourage the occurrence of pedestrian mugging.

Therefore the investigation carried out regarding pedestrian mugging in different periods of the day and their relationship with physical-spatial attributes of segments in most central boroughs of Porto Alegre offers more detailed information and may contribute to the knowledge about the relationship between pedestrian mugging and urban design characteristics.

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