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Do moral communities have a spatial dimension? A spatial exploratory analysis of places of worship and violent crime in the city of Recife, Brazil.

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Do moral communities have a spatial dimension? A spatial exploratory analysis of places of worship and violent crime in the city of Recife, Brazil

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16 1 Introduction

18 Violent crime is a widespread phenomenon with negative impacts on many
19 spheres of life and society. Although the rate of homicides worldwide has grown
20 at a slower rate than the population in the past few decades, the number
21 of people killed in homicides still increased from 362,000 in 1990 to 464,000
22 in 2017 (United Nations Office on Drugs and Crime 2019a). Furthermore,
23 variations in the prevalence of violent crime tend to be extremely uneven.
24 The Americas, with a population of approximately 793.8 million people in
25 2019 (or about 10.3% of the world population), accounted for approximately
26 173,000 homicides in 2017, or approximately 37.3% of all homicides in the
27 world. Within the Americas, Brazil (along with Venezuela, Colombia, and
28 Mexico) is one of the largest countries in the region with high homicide rates.
29 And there are notable variations at the sub-national and intra-metropolitan
30 levels as well. In fact, understanding the variations in the prevalence of violent
31 crime is recognized as key to achieving policy goals:
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33 High levels of homicidal violence are concentrated in geographic
34 and demographic “pockets”, so achieving target 16.1 of the Sus-
35 tainable Development Goals requires interventions within the
36 specific regions, countries, communities and population groups
37 that are most at risk (United Nations Office on Drugs and Crime
38 2019a, 35)
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40 This concern is not idle: violent crime tends to be more acute in those re-
41 gions most in need of development. On the one hand, violent crime represents
42 an economic and social drag (Becker and Kassouf 2017). The impacts are mul-
43 tifaceted, since they affect people’s well-being, either through the loss of human
44 life, mental health, and limitations in the right to public spaces (Doran and
45 Burgess 2011), or through disturbances in schooling and academic achievement
46 (United Nations Office on Drugs and Crime 2019b). In turn, these negative ef-
47 fects combine to create the unfortunate conditions that tend to breed criminal
48 behavior, thus creating a vicious cycle of economic disadvantage and violence
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(United Nations Office on Drugs and Crime 2019b). It is not surprising, given these peculiarities, that researchers have joined calls for increased attention to the study of the patterns of violent crime in Low and Middle Income Countries (LMIC; Murray, Cerqueira, and Kahn 2013).

Added to the scenario, formal social control institutions in countries like Brazil often leave something (or much) to be desired: while in practice they should inhibit criminal behavior, they suffer from deep deficiencies that end up eroding the deterrent power of the justice system. Serious institutional problems include the inefficiency of the police, the lack of national legislation, the glacial pace of judicial processes, and the weak situation of the prison system in the country (Menezes et al. 2013). This makes it even more urgent to understand the role of *informal social controls*, i.e., the ability of community organizations such as schools, clubs, and neighborhood associations to suppress crime by strengthening the capabilities of neighbors to control inappropriate behavior (Groff 2015).

In order to understand the factors that can potentially help to deter crime, beyond formal control, it is important to identify empirical regularities. Criminological factors include concrete elements (such as the presence of arms or drugs, or elements of the built environment), and also figurative factors, which include the social cost of deviant behavior. Accordingly, a number of studies have investigated various aspects of the environment and neighborhood design (e.g., Foster, Giles-Corti, and Knuiman 2010; He, Páez, and Liu 2017; Loukaitou-Sideris et al. 2001), whereas other studies have focused on exposure to environmental attributes that signal weakened norms, such as liquor and tobacco outlets (e.g., Brower and Carroll 2007; Deryol et al. 2016; Lipton et al. 2008; Quick, Law, and Luan 2017).

Yet another fruitful avenue for research, and one that has only recently begun to be explored, is the presence of environmental attributes that can help to reinforce moral norms, such as schools and churches (e.g., Abdullah et al. 2018; Davignon and Thomson 2015; Furr-Holden et al. 2010; Traunmuller 2011). It is thus that in a recent paper, Warner and Konkel (2019) note that the role of places of worship, as distinct entities from the members of the congregations, have received less attention in empirical and theoretical research for their deterrence potential. The role of these institutions might be particularly important in places where formal state institutions lack the means or the will to enforce norms in a consistent way - as is the case in Brazil (Garmany 2014).

With the above considerations in mind, the objective of this paper is to investigate whether and how places of worship correlate spatially with criminal events, or in other words, to investigate whether their signals as moral communities have a discernible spatial dimension. Our argument is as follows:

1. Since places of worship are associated with normative codes of behavior, can they by their presence contribute to create moral communities? The mechanisms for this are explained by Groff (Groff 2015) in terms of “Eyes

1 on the Street" (see Jacobs 1961, 1968; Appleyard 1980) and Human Territorial Functioning (Taylor 1988, 1998).

- 2 2. If so, what is the distance decay of said moral community effect? Is it
3 uniform over a certain distance, such that it could be well approximated
4 by areas, or does it vary?

5 The empirical analysis uses geographically detailed data from the city of
6 Recife in the state of Pernambuco, in Brazil's Northeast. Recife is a large and
7 important metropolitan area in a historically poor region, and afflicted by
8 high levels of violent crime, having the dubious honor of being one of five state
9 capitals with the highest rates of homicide in the period under study (Menezes
10 et al. 2013). The empirical strategy is to use spatial analysis to explore the
11 potential geographical relationships between violent criminal events, on the
12 one hand, and places of worship and a selection of commercial establishments
13 that serve as controls, on the other.

14 Note that this is a reproducible research document. The analysis is imple-
15 mented using the R statistical computing language, and documents to replicate
16 the analysis, in addition to all data necessary, are available from a repository¹.

22 **2 Background**

23 2.1 Theoretical Perspectives on Religion and Crime

24 Why do humans behave morally? For millennia, it has been the role of religion
25 to provide the basic tenets of morally acceptable behavior: thou shalt not
26 kill et al., and their equivalent in many world religions (e.g., Donovan 1986).
27 Enforcement of such tenets implies different mechanisms, including *sin*, *haram*,
28 *karma*, and *tapu*, with punishment delivered by hellfire and exile to *Jahannam*
29 or *Gehenna*, to mention just some choice places of torment. In addition to
30 acting as *de facto* social policy for much of history, many of these religious
31 tenets still have the force of law in many cultures and regions - and even where
32 they do not, they are held by some researchers and policy experts to be helpful
33 complements to reduce crime in any case (e.g., Durrant and Poppelwell 2017;
34 Johnson 2011). The hypothesis that religion can act as a factor that deters
35 and reduces criminal behavior, therefore, has prompted the scientific study of
36 the effectiveness of religion on moral behavior (Hoffmann 2015).

37 An early effort to theorize the effect of religion on criminal behavior was
38 the *hellfire hypothesis* of Hirschi and Stark (1969). The focus of this hypothesis
39 is the threat of extra-temporal (and possibly eternal) punishment, and how
40 this threat can deter believers from commandment-breaking (also see Pascal's
41 wager). Accordingly, Hirsch and Stark (1969) posit that negative correlations
42 between crime and religion are a consequence of a sense of commitment with
43 normative values, a commitment that is ritually reinforced in a regular fashion
44 (e.g., the liturgical rite of peace in Catholic Mass). Rohrbaugh and Jessor

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49 ¹ https://drive.google.com/open?id=1tuJM4Mhi0Ftq3ZEwjv6RP9v03veGjIR_

(1975), for instance, note that by attributing to divinity (or some other supraterran entity) the supreme force of punishment, religion helps to build a sense of obduracy, or “hardening” against temptation.

Despite its intuitive appeal, research has not provided much direct evidence for the hypothesis of hellfire (Hoffmann 2015, 1). In a bizarre twist, even mainstream doctrines (such as absolution) may in fact encourage beliefs that neutralize the fear of *terrenal* punishment, and thus turn out to be criminogenic (e.g., Topalli, Brezina, and Bernhardt 2013). More deviant cases can even recast criminal behavior as a form of spiritual insurgency (Chesnut 2017). Counterexamples like this notwithstanding, researchers remain open to the possibility that “religion may still serve as a social control mechanism by encouraging conventional beliefs, monitoring behaviors, enhancing family attachments, or providing conventional activities” (Hoffmann 2015, 1). In this way, the hypothesis of *moral communities* (Stark 1996) recognizes that social integration is essential for increasing social control, thus reducing the practice of behavior that is not in accordance with current norms. Rohrbaugh and Jessor (1975) also emphasize that religion acts as social control since it defines what is an appropriate attitude according to moral values, thus making moral communities a close relative of the concept of *informal social control*, defined as “the ability of social groups or institutions to make norms or rules effective”² (Reiss 1951, 196; cited in Groff 2015, 91).

The hypothesis of moral communities has over the years been used to examine a variety of outcomes of interest. Recent examples include Stroope and Baker’s (2018) exploration of religiosity and self-rated health; Davignon and Thomson (2015) with their research on institutional context and the religiosity of students; and the study of religion as a source of trust of Traunmuller (2011). This is in addition, of course, to numerous studies on criminal behavior such as Eitle (2011), an author who explored the deterrence power of religion on gambling; Lee and Bartkowiak’s (2004) investigation of juvenile homicide in rural areas; and the research of Regnerus (2003) on adolescent delinquency. The hypothesis of moral communities as a form of informal social control, on the other hand, has been less studied from a geographical perspective, and it is only recently that has attracted the attention of researchers. Groff (2015), for instance, discusses informal social control as a phenomenon that can plausibly

² The discussion about disorder is directly related to the idea of social control. According to this perspective, control mechanisms to contain deviant actions are considered indispensable [@Rodrigues2012medo]. This theory assumes that the deviant act is seen as normal in social organization, and coercive forces are needed to limit such impulses. This control can be exercised through formal institutions, as well as through informal mechanisms. It would be a set of norms as well as positive and negative sanctions, which are specified throughout the socialization process, which aims to establish values and build the individual’s morals, disciplining society and subjecting individuals to standards and principles predefined. As the individual finds himself more and more inserted in the social context, less will be the chances of criminal behavior. From this perspective, the existence of bonds of solidarity and trust would be relevant for the effective exercise of supervision over crime in the neighborhood. Informal control is then linked to the ability of a neighborhood to establish communication and surveillance networks, interfering in cases of criminal actions and increasing security in the region.

1 operate at different geographical scales, from the level of the home and family,
2 through the street block and neighborhood, possibly to other scales such as
3 the county. In this way, Nie and Yang (2019) remark on a recent paper on the
4 lack of research conducted to study how the religious context of a geographical
5 area (e.g., a county) may influence (youth smoking) behavior (p. 2). This point
6 is echoed by Warner and Konkel (2019), who moreover recommend the use of
7 smaller units of analysis (e.g., Census Block Groups), in an effort to reduce
8 aggregation bias (see Hipp 2007), but more importantly because the processes
9 defined by social disorganization theory³ are thought to occur at relatively
10 small geographical scales.
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12 Groff (Groff 2015), in particular, explains the small-scale mechanisms that
13 could be in operation in terms of “Eyes on the Street” and Human Territorial
14 Functioning. “Eyes on the Street” (see Jacobs 1961, 1968; Appleyard 1980)
15 refers to involvement in small civic acts by users of public spaces, which signal
16 social organization to an observer. Community engagement, moreover, is en-
17 gaged at small scales, as shown by authors that include Appleyard (1980)
18 and more recently Grannis (2009). Human Territorial Functioning (HTF; Tay-
19 lor 1988, 1998) also provides a valuable perspective on social informal control
20 This concept posits that territorial functioning is a product of the shared per-
21 ceptions of individuals in regards to places, and how these perceptions are
22 shaped by the physical, social, and cultural environments. For example, Paez
23 (2013) discusses how perceptions of safety are the outcome of a socially inter-
24 active process, and shows how this process leads to spatial patterning at very
25 small-scales. The preceding review, as well as other research (2019), makes
26 clear the need for research at various geographical scales. From a theoret-
27 ical perspective, the social mechanisms that underpin the hypothesis of moral
28 communities and informal social control can happen at various geographical
29 scales, some of which previous research has already addressed: the work of Nie
30 and Yang (2019), for one, highlights the role of processes detectable at a rel-
31 atively high level of aggregation, whereas Warner and Konkel (2019), looking
32 specifically at the effect of places of worship, bring the study closer to the level
33 of the neighborhood.
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39 ³ The social disorganization theory (Shaw e McKay, 1942) presents the social structure as
40 an indispensable factor for the elaboration of theoretical and methodological models related
41 to crime in urban neighborhoods. According to Villareal e Silva [@Villarreal2006social],
42 “neighborhoods characterized by dense social networks will experience greater trust among
43 residents and cooperation in the enforcement of social norms against crime. Disadvan-
44 taged neighborhoods are thought to have fewer social ties among residents and lower rates
45 of organizational participation”. The argument is that community characteristics such as
46 poverty, ethnic heterogeneity and residential mobility disrupt the social organization of ur-
47 ban neighborhoods in such a way as to reduce their capacity to exercise social control [@Ro-
48 drígues2012medo]. Thus, aspects such as residential instability or low socioeconomic status
49 would contribute to the weakening of the community organization, increasing crime rates.
50 This theory highlights the importance of the geography of crime and the characteristics of
51 disorder in its analysis.
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1 2.2 Religion in Brazil
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Brazil is a predominantly Christian country. The first national census that collected information on religion was in 1872, a year when practically the entire population (99.72%) identified themselves as Catholic. In the 1940 census, when the religion question was asked again, Catholicism was still the dominant religion with 95.2% of Brazilians declaring themselves as Catholics. The dominance of Catholicism in the religious life of Brazil is unsurprising given the country's past as a former colony of a Catholic power (Portugal). However, the religious makeup of the population started to become less homogeneous in the second half of the twentieth century. Among other offerings in the market place of spiritual ideas, Spiritism stands out. The Spiritist Doctrine was founded in nineteenth-century France by Allan Kardec as a way of understanding the world and its relations with the "beyond", in a curious mix of pseudo-scientific language, philosophy, and religion (Arribas 2011a). Spiritism arrived in Brazil in the middle of the nineteenth century, and since then it slowly spread in large and medium-sized cities. Today, Spiritism is the third largest religious segment in Brazil, after Catholicism and Evangelical Christianity, and shares with these religions the Christian principle of charity through pious assistance.

Another signal event in the development of religion in Brazil was the arrival of Pentecostal Protestant churches, such as the Christian Congregation of Brazil in 1910 and the Assembly of God in 1911. Initially, these religious denominations did not make important inroads in Brazilian society (as evidenced by the 1940 census). However, in the context of rapid industrialization and major urbanization, they contributed to the change in the religious landscape along with other religions (Souza 2019): according to the 2010 census the configuration of the religious scene in Brazil had changed considerably from the previous century: 64.6% of the population identified as Catholic and 22.2% as Evangelical Christians. The acceleration of this demographic change was directly related to successful proselitism by Evangelical churches: The Assembly of God, for instance, is a church that grew considerably to total more than 12.3 million adherents. This church is represented extensively in many regions of the country, following a system of loosely allied ministries. With a charismatic profile and the lack of a centralized authority, growth of this church has occurred mainly through subdivision into numerous small and autonomous churches. These churches have in common the Prosperity Gospel and an emphasis on economic entrepreneurship (e.g., Mora 2008). They also do not shy away from partisan political action.

In general, there have been two major changes in Brazil regarding religious issues: the slow decline of Catholicism and the rapid growth of Evangelical Christianity. These changes are evident in the daily life of the average Brazilian, either through the radio or through TV programs, which give more and more space to religious doctrines. At the same time, there has been an increase in cases of religious intolerance in Brazil, generating violence acts against temples, objects of worship, and people (e.g., Souza 2019; Fonseca 2018).

In what follows, we propose to adopt a disaggregated approach by considering the intensity of criminal events with respect to places of worship. This requires micro-level data both of crimes and places of worship, and the use of appropriate spatial analytical tools for point patterns, as discussed next.

3 Empirical Strategy

As noted above, previous research that has investigated the presence of churches from a geographical perspective has used data aggregated at different scales. In the case of Nie and Yang (2019), the unit of analysis was the county, whereas Warner and Konkel (2019) used Census Block Groups, a much smaller unit of analysis. Research in spatial criminology, on the other hand, has studied criminal events as point patterns since at least the work of Levine et al. (1986) investigated the concentration of criminal events in the proximity of bus stops. Since then, many other works have applied tools of spatial point pattern analysis to investigate the empirical properties of the distribution of crime. This includes Craglia et al. (2000) who used the Ripley's K-function (Ripley 1976) to investigate clustering processes, and Rogerson and Sun (2001) who applied nearest neighbor techniques to the study of arson. More recent studies of crime as point patterns are Nakaya and Yano (2010), Kiani et al. (2015), and Malleeson and Andresen (2015).

Readers interested in point pattern analysis techniques are urged to consult the still valuable Bailey and Gatrell (1995) or for an up-to-date and in-depth coverage of the topic, the excellent text by Baddeley et al. (2015). In this paper we will concentrate on one property of point processes, namely the intensity. Suppose that the outcome of interest is the number of events per unit area $Y(\mathcal{A})$. This could be, for instance, the number of criminal events observed in an arbitrary area. The intensity of a point pattern then is as follows:

$$\lambda(s) = \lim_{ds \rightarrow 0} \frac{E[Y(ds)]}{ds}$$

where $\lambda(s)$ is the intensity of the process at point s , given by the expected number of events in a small area ds around s , as the area becomes arbitrarily small. If the process is homogeneous (i.e., the intensity is a constant over space), an apt estimator of the intensity is the global intensity, simply the number of events divided by the area of the region under analysis:

$$\hat{\lambda} = \frac{n}{|\mathcal{A}|}$$

When the process is not homogeneous, other estimators are more appropriate. In the analysis to follow we use two estimators of intensity: conditional quadrat counts and relative distribution estimate. These techniques are briefly discussed next.

 1 3.1 Conditional Quadrat Counts
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Quadrat counts is a relatively simple technique to analyze spatial variations in the intensity of a point process. It operates by partitioning the region under study \mathcal{A} into subregions $\mathcal{A}_1, \dots, \mathcal{A}_m$. These subregions are mutually exclusive, and their union is identical to \mathcal{A} . In the simplest case, the subregions have equal area. The number of events within each subregion (i.e., $n_{\mathcal{A}}$) divided by the area of the subregion (i.e., $|\mathcal{A}|$) is a local estimate of the intensity:

$$\lambda(\mathcal{A}_i) = \frac{n_{\mathcal{A}_i}}{|\mathcal{A}_i|}$$

A test for homogeneity consists of assessing whether the intensity of the point process at the quadrats is uniform:

$$\lambda(\mathcal{A}_1) = \dots = \lambda(\mathcal{A}_m)$$

Using quadrats of equal size is a convenient simplification, but in principle the areas could be different - in which case the count of events would be proportional to the area of the quadrat under homogeneity. An interesting variation of this technique is conditional quadrat counts, whereby the partition of regions $\mathcal{A}_1, \dots, \mathcal{A}_m$ is done to reflect an underlying covariate of interest, say Z . By introducing a covariate as a partitioning criterion, it becomes possible to calculate estimators of the intensity of quadrats at different levels of the value of the covariate. For exploratory purposes, we can plot average intensity by quadrat, and compare to the global intensity.

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 30 3.2 Relative Distribution Estimate
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Conditional quadrat counts allow us to explore whether the intensity of the process depends on a covariate Z . A different way of expressing this is as follows:

$$\lambda(s) = \rho(Z(s))$$

In this case, the intensity is a function ρ that maps how the intensity depends on covariate Z . Non-parametric estimation of ρ uses the ratio of the density of covariate values at the locations of the point process, relative to the *spatial distribution function* G , the density of covariate values at random locations (see Baddeley, Rubak, and Turner 2015, 179).

The density of covariate values at the locations of the is obtained by means of a kernel density estimator, for example:

$$\lambda_0(s) = \frac{1}{|\mathcal{A}|} \sum_{i=1}^n \kappa(Z(s_i) - z)$$

where s_i are the locations of the points.

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1 On the other hand, G which is the cumulative distribution function of Z
 2 at random point S uniformly distributed in \mathcal{A} :

$$4 \quad G(z) = \frac{1}{|\mathcal{A}|} \int_{\mathcal{A}} I\{Z(s) \leq z\} ds \\ 5 \\ 6$$

7 where I is an indicator function that takes the value of 1 if the argument is
 8 true, and the value of 0 otherwise. In practice, the spatial distribution function
 9 is approximated based on a discretization of space using a fine grid of pixels
 10 as follows:

$$11 \quad G(z) = \frac{\#\{\text{pixels } s : Z(s) \leq z\}}{\#\text{pixels}} \\ 12 \\ 13$$

14 Therefore, an estimator of ρ is as follows:

$$15 \quad \rho(z) = \frac{1}{|\mathcal{A}|G'(z)} \sum_{i=1}^n \kappa(Z(s_i) - z) \\ 16 \\ 17$$

18 where the derivative G' can be approximated by differentiating a smoothed
 19 estimated of G . Other estimators are discussed by Baddeley et al. (Baddeley,
 20 Rubak, and Turner 2015, 180).

21 It is possible to adjust the relative distribution estimate by means of a
 22 baseline; a baseline in this case can be a function of other covariates that
 23 might confound the estimates of the relative distribution, so that the relative
 24 intensity $\lambda(s)/B(s)$ can be assumed to depend only on covariate Z . Therefore:

$$25 \quad \lambda(s) = \rho(Z(s))B(s) \\ 26 \\ 27$$

28 where $B(s)$ is a baseline function. It can be seen that $\rho(z) = 1$ is the baseline
 29 intensity; values of $\rho(z) > 1$ correspond to intensities higher than the baseline
 30 as a function of $Z(u)$, whereas values of $\rho(z) < 1$ correspond to intensities
 31 lower than the baseline, again as a function of $Z(u)$.

33 3.3 Interpretation

34 Both quadrats and the relative distribution function are estimators of inten-
 35 sity. In the case of quadrats, the estimator is the number of events in the
 36 quadrat divided by area of the quadrat (conditional quadrat counts use ir-
 37 regular quadrats that are defined based on some control variable, in our case
 38 SED). In the case of the relative distribution, the output is an estimate of
 39 intensity conditioned on distance from a signal event, e.g., a place of worship.
 40 The relative distribution can be adjusted by means of a baseline function $B(s)$,
 41 which is also an estimate of intensity but conditioned on some control covariate
 42 (in our cases SED). Therefore, the interpretation of the relative distribution
 43 with a baseline function is as a ratio of the intensity with respect to distance,
 44 to the baseline intensity according to the control covariate. If the ratio, which
 45 is dimensionless, is 1, then intensity as a function of distance is equal to the
 46 baseline intensity.
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2 **Table 1** Characteristics of Violent Crime in Recife, July, 2008 - June, 2009
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	Percentage
Gender of Victim	
Man	91.35
Woman	8.65
Type of Crime	
Murder	97.82
Robbery	2.00
Body injury followed by death	0.18
Ethnicity of Victim	
Black and Brown	95.11
Yellow and White	1.27
Not Reported	3.62
Age of Victim	
1 to 12 years	0.18
13 to 17 years	11.31
18 to 30 years	61.70
31 to 65 years	25.84
65 years and older	0.73
Not Reported	0.24
Weapon Used	
Firearm	87.51
Other	12.49

4 Case Study: Context and Data

The study is of the city of Recife, the capital of the state of Pernambuco in the Northeast region of Brazil. With a population of 1,550,390 million inhabitants in 2010, Recife is one of the main Brazilian metropolises, exerting a great economic influence in neighboring regions. However, the city experiences a serious problem with violent crime, and has the dubious honor of being one of the five capital cities in Brazil with the highest homicide rates in the period under study⁴ (Menezes et al. 2013).

In the current context, the term “violent crime” is an umbrella for several forms of infractions to the penal code. Following recommendations of the National Secretariat of Public Security of the Ministry of Justice of 2006, these are Violent Lethal and Intentional Crimes (VLIC; which includes intentional homicide), theft followed by death (robbery), and corporal injury followed by death. The data on LIVC were extracted from the Police Information System of the Secretariat of Social Defense of Pernambuco (INFOPOL / SDS-PE), which is the most reliable, detailed, and comprehensive information on violent deaths in the region.

The data are organized at the individual level and it is possible to obtain information about the crime event location, day of the week, day of the

⁴ The appendix included information that allows a more in-depth characterization of the city of Recife: population distribution, income, inequality, urban facilities (education and health) and location of residential areas.

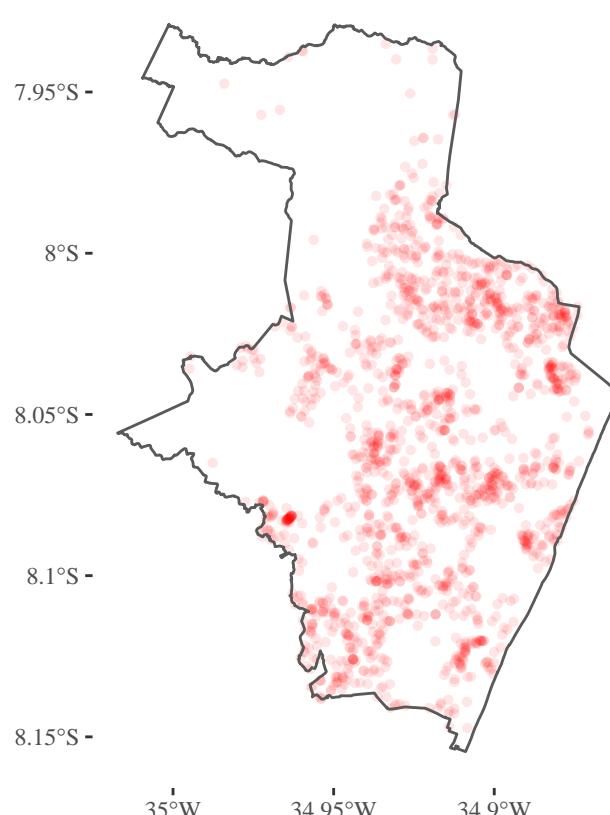


Fig. 1 Location of Lethal and Intentional Violent Crime in Recife, July, 2008 - June, 2009

month, period of the day, as well as gender, age, and race of the victim. The database used in this study comprises the period from July 1, 2008 to June 30, 2010. Some descriptive statistics regarding this dataset are reported in Table 1, where it can be seen that overall, about 91% of the victims of LIVC in the period analyzed were men. In addition, most of the victims were black or brown, and the youth population between the ages of 18 and 30 is the most affected by violent crime. Lastly, it should be noted that about 88% of the criminal events under analysis involved firearms. Figure 1 shows the spatial distribution of the 1,657 LIVC crimes that occurred in the city of Recife between July, 2008 and June, 2010.

Information about places of interest was obtained from the National Register of Addresses for Statistical Purposes (CNEFE - Census 2010), which lists 78,056,411 urban and rural addresses, distributed among the 316,574 census tracts. This is the first database of its kind produced by IBGE, and the first version was produced at the time of the 2000 Census. The way addresses are

described in the National Register is very rich, and it is possible to identify the names of the places of worship including their denomination. Georeferencing was used to geolocate each place of worship. In this way, a total of 1,719 places of worship were geolocated in the city of Recife.

In addition to places of worship, the National Register of Addresses for Statistical Purposes was queried to extract facilities other than places of worship. To study the spatial relationship between churches and crime, a control group was built and then a comparison of the empirical distribution was carried out. Gilberston and Hayes (2012) highlight that different configurations of urban space affect how people perceive the environment around them. In this perspective, churches are continually affecting the impression that people have of a region. Thus, we assume that churches have unique characteristics that may or may not inhibit the occurrence of a criminal act: they are urban constructions that are not neutral in relation to crime. On the other hand, there are urban facilities that do not provide any specific reason to justify the fact that the crime occurs closer or further from these buildings. Thus, it can be thought that any urban construction belongs to one of the following distinct situations: neutral or non-neutral to crime. Pharmacies, ice cream parlors and bakeries will be used in the construction of the control group and will be considered neutral. The comparison between the distributions of non-neutral and crime-neutral establishments forms the empirical basis of the study. The choice of establishments that make up the control was based on two criteria: (a) being neutral to crime and (b) having a spatial distribution similar to non-neutral establishments. The strategy used is to compare similar establishments about their spatial distribution, but different in relation to their neutrality profile in relation to crime, seeking to simulate the existence of a case and a control group. The case will be composed of churches, while the control will be pharmacies, ice cream parlors and bakeries.

As discussed above, the idea is to identify points of reference that can be used as controls, having a neutral morality profile. For the sake of the present study, we selected pharmacies, ice cream shops, and bakeries to construct our control group. These three types of establishments comply with the criteria of being morally neutral and having a spatial distribution commensurate with places of worship.

Figure 2 shows the spatial distribution of the places of worhsip and control establishments in the city of Recife. Note the similarity between the maps. As expected, there are differences in the number of points, but the locations of cases and controls are quite similar: the distribution of the churches, as well as of the commercial establishments follow the same pattern, being correlated with the spatial distribution of the population (see in the appendix). Since such urban constructions respond to society's demand, they tend to be located close to population agglomerations.

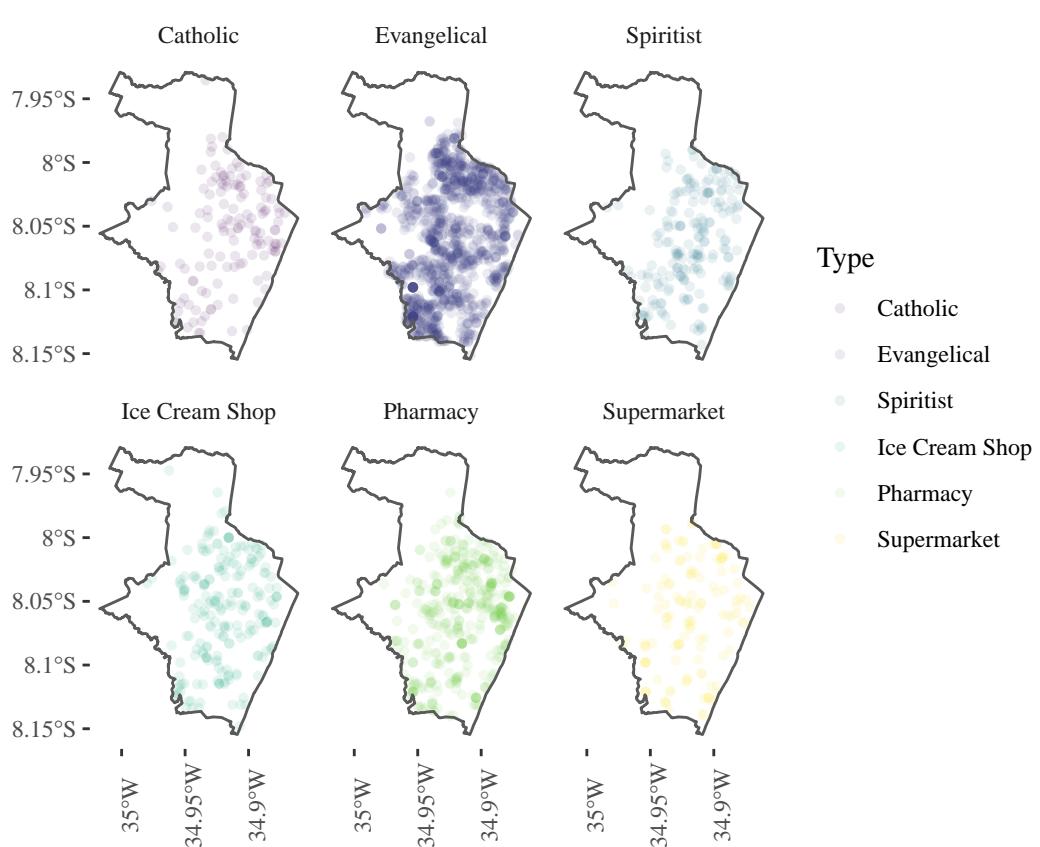


Fig. 2 Location of Places of Worship and Commercial Establishments in Recife

5 Analysis and results

5.1 Socio-Economic Deprivation

The first step in our analysis is to obtain an indicator of Socio-Economic Deprivation (SED). Socio-economic deprivation is known to correlate positively with crime, as it often reflects relevant criminogenic factors such as poverty and family disruption (He et al. 2015). In the present case, we have for the city of Recife information about the variables shown in Table 2 at the level of *setores*, a small Brazilian census geography.

As seen in the table, Recife is a city with large socio-economic and demographic disparities; for example, the *setor* with the highest median income has a median income that is 6,517% higher than the median income in the *setor* with the lowest median income. Whereas there are *setores* where the proportion of population who are unemployed is zero, there are *setores* where almost

1
2 **Table 2** Descriptive statistics of some key socio-economic and demographic variables in
3 Recife

Variable	Min	2nd Quartile	Median	Mean	3rd Quartile	Max	PC Factor 1 Loadings
Median Income	122.05	337.40	581.67	1031.09	1283.79	7954.19	-0.42
Proportion Unemployed	0.00	0.05	0.10	0.10	0.14	0.59	0.56
Proportion Poverty	0.00	0.05	0.11	0.12	0.17	0.63	0.58
Proportion Single Mother	0.00	0.33	0.37	0.37	0.41	0.70	0.17
Proportion Young Single Mother	0.00	0.01	0.02	0.02	0.02	0.21	0.38
Population Density	0.00	10564.16	16333.62	19230.23	25106.07	181642.55	0.03

12 *Note:*

13 The variable for young single mothers is for women aged 15-25

14 The first principal component accounts for 44.9% of the variance

17 60% of the population are unemployed (which for some may mean they are
18 part of the informal economy). Likewise, there are *setores* where almost 70% of
19 the population lives in poverty. In addition to these economic indicators, two
20 variables are used to represent family disruption, the proportion of families
21 whose head is a single mother, and the proportion of families whose head is
22 a *young* single mother, that is, a woman between the ages of 15 and 25. As
23 can be seen, there are *setores* with approximately 70% of households led by
24 single mothers, and of these, over 21% are led by younger women, indicating
25 a high degree of family disruption. Unlike other places, where higher popula-
26 tion density is associated with more poverty, the distribution of this variable
27 in Recife is more mixed: middle income and higher income households favor
28 high density development in many parts of the city. The spatial distribution
29 of these variables can be seen in Figure 3.

31 For the analysis, we use Principal Component Analysis, a data reduction
32 technique, to obtain an indicator of Socio-Economic Deprivation, essentially
33 the first principal component in the output. The loadings of this factor (Ta-
34 ble 2) indicate that high Socio-Economic Deprivation is a combination of (in
35 terms of importance): high levels of poverty, high levels of unemployment, and
36 low median income, followed by high levels of family disruption, in particular
37 proportion of families led by young single mothers. This factor accounts for
38 almost 45% of the variance.

39 Figure 4 displays the geography of Socio-Economic Deprivation in Recife,
40 after classifying *setores* by quintiles, whereby the “High” class corresponds to
41 *setores* in the top 20% of the Socio-Economic Deprivation indicator, and the
42 “Low” class corresponds to *setores* in the bottom 20% of the Socio-Economic
43 Deprivation indicator. The figure shows a veritable mosaic of affluence and
44 deprivation, with high deprivation areas directly in contact, and in some cases
45 almost completely surrounded, by low deprivation areas. This geographical
46 pattern of inequality, on the other hand, seems to be characteristic of Brazilian
47 metropolitan regions, where enclaves of wealth and *favelas* (i.e., urban slums)
48 can be found in close proximity (see for example Feitosa et al. 2007).

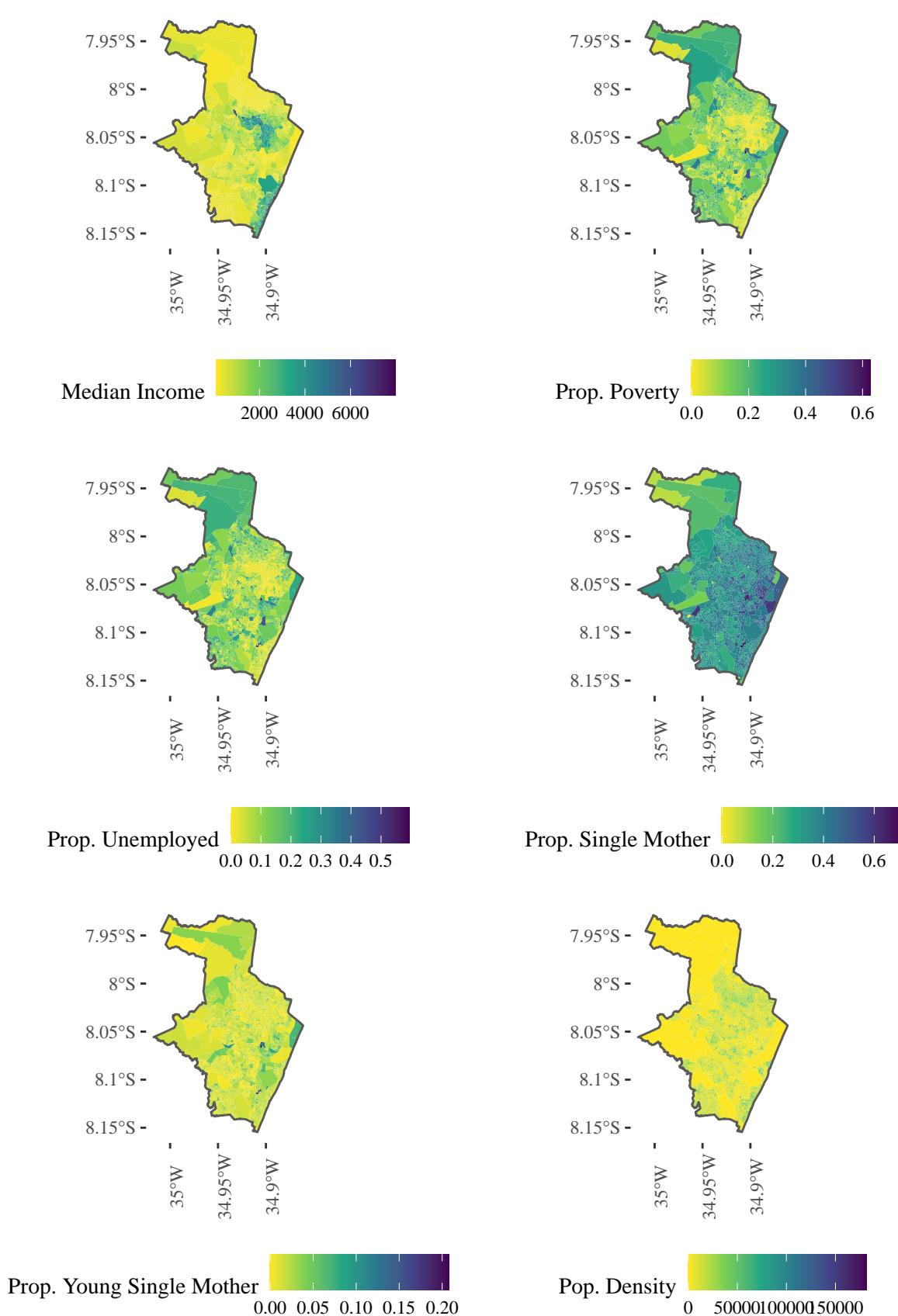


Fig. 3 Spatial distribution of socio-economic and demographic variables in Recife

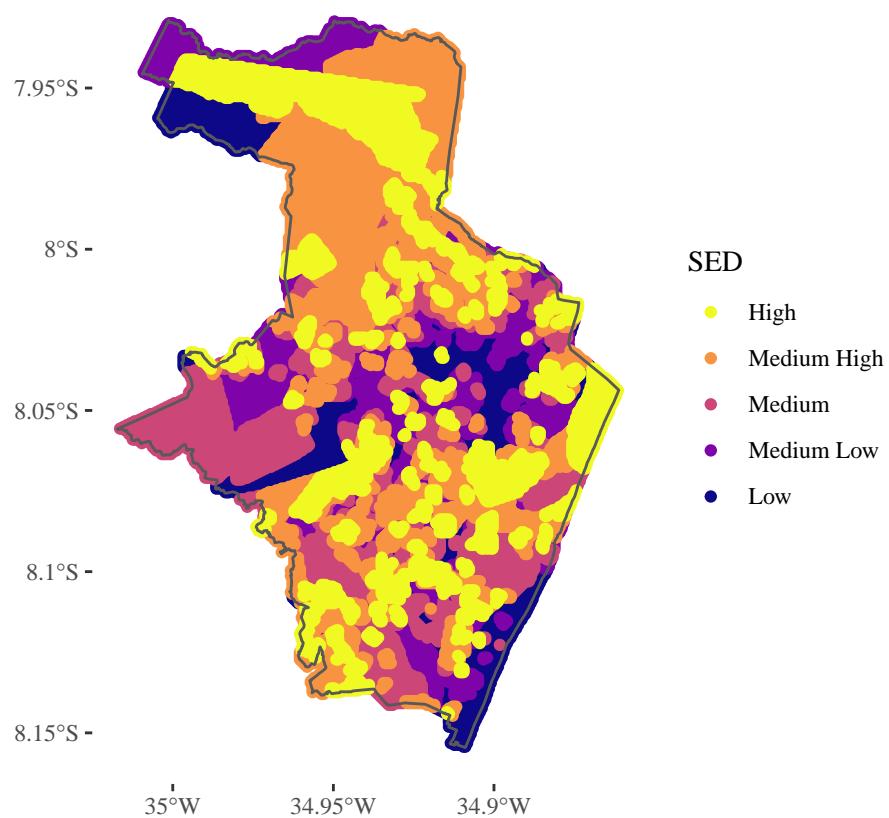


Fig. 4 Socio-Economic Deprivation in Recife classified by quintiles

5.2 Conditional Quadrat Analysis

Once the indicator of Socio-Economic Deprivation has been obtained, as outlined above, it can be used for conditional quadrat analysis. As previously described, the quadrats are irregular areas that are defined based on a covariate, in this case the quintiles of the Socio-Economic Deprivation indicator. Each color in Figure 4 is a “container” for counting events. In essence, this entails counting the number of events at each level of the covariate, and then calculating an estimator of the intensity. The global intensity of each type of event, as well as the quadrant counts and intensity at each level of SED can be consulted in Table 3.

Figure 5 shows the results of conditional quadrat counts for Lethal and Intentional Violent Crime. The dotted line indicates the global intensity, simply the total number of criminal events divided by the area of the region. It can be seen that the intensity of crime clearly increases with Socio-Economic De-

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Table 3 Conditional quadrat counts results

Event	Global Intensity	SED Quintile	Quadrat Count	Intensity
Violent Crime	7.58e-06	Low	201	4.6e-06
		Middle Low	295	6.75e-06
		Middle	364	8.33e-06
		Middle High	479	8.65e-06
		High	318	9.94e-06
Catholic	5.99e-07	Low	32	7.32e-07
		Middle Low	26	5.95e-07
		Middle	33	7.55e-07
		Middle High	29	5.24e-07
		High	11	3.44e-07
Evangelical	6.3e-06	Low	209	4.78e-06
		Middle Low	304	6.95e-06
		Middle	334	7.65e-06
		Middle High	345	6.23e-06
		High	185	5.78e-06
Spiritist	8.65e-07	Low	37	8.46e-07
		Middle Low	50	1.14e-06
		Middle	40	9.16e-07
		Middle High	40	7.22e-07
		High	20	6.25e-07
Ice Cream	9.47e-07	Low	45	1.03e-06
		Middle Low	60	1.37e-06
		Middle	39	8.93e-07
		Middle High	37	6.68e-07
		High	26	8.12e-07
Pharmacies	2e-06	Low	116	2.65e-06
		Middle Low	122	2.79e-06
		Middle	91	2.08e-06
		Middle High	84	1.52e-06
		High	25	7.81e-07
Super Markets	5.72e-07	Low	27	6.17e-07
		Middle Low	32	7.32e-07
		Middle	38	8.7e-07
		Middle High	16	2.89e-07
		High	12	3.75e-07

privation, and the intensity in areas with the highest levels of Socio-Economic Deprivation is 216.2% higher than in places with the lowest levels of Socio-Economic Deprivation. This is as expected, as research has consistently found correlations between Socio-Economic Deprivation and a variety of negative health outcomes, including homicide (Ichihara et al. 2018). A χ^2 test of independence on the quadrat counts yields a value of $p \leq 0.0001$ (four degrees of freedom), which comfortably rejects the null hypothesis of homogeneity of intensity of crime by level of Socio-Economic Deprivation.

Next, we repeat the analysis of conditional quadrat counts, but now for the six types of events of reference. As discussed above, this included three

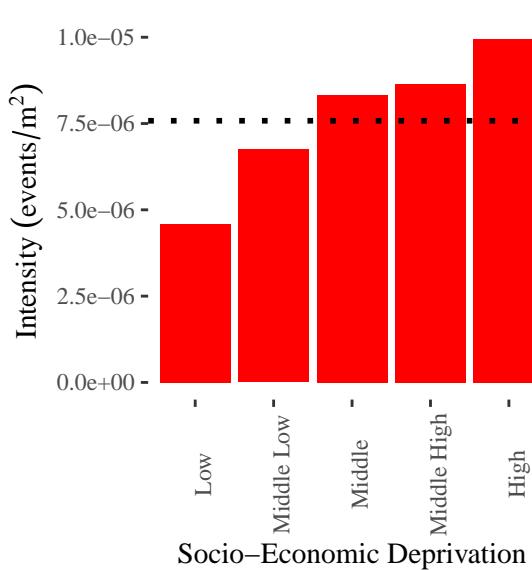


Fig. 5 Intensity of crime by level of Socio-Economic Deprivation; the dotted line indicates the global intensity of crime

types of places of worship which are of interest from the perspective of moral communities, and three types of commercial establishments that we posit are morally neutral. The results of estimating the intensity of the process by means of conditional quadrat counts are shown in Figure 6.

The first thing that we note are the variations in global intensity of places of worship, with Evangelical places of worship being the most intense of the three. There are no clear variations in the locational pattern of Catholic places of worship by level of Socio-Economic Deprivation. Evangelical places of worship, on the other hand, tend to be found more frequently in places with middle-low and middle levels of Socio-Economic Deprivation, a pattern also discernible, albeit barely, for Spiritist churches. Interestingly (see Table 4) χ^2 tests of independence on the conditional quadrat counts fail to reject the hypothesis of homogeneity for Catholic and Spiritist churches, and it is only in the case of Evangelical places of worship that we detect the possibility of locational patterns that vary by level of Socio-Economic Deprivation.

Three types of commercial establishments also appear to display inhomogeneous locational patterns (Table 4), with the χ^2 test of independence emphatically rejecting the null hypothesis. As seen in Figure 6, ice cream shops tend to be found more frequently in places with middle-low Socio-Economic Deprivation, and less frequently in places with middle-high Socio-Economic Deprivation. Pharmacies show a clearer trend, with locational patterns that tend to favor places with low Socio-Economic Deprivation. Finally, supermarkets are found less frequently in places with middle-high and high Socio-Economic Deprivation.

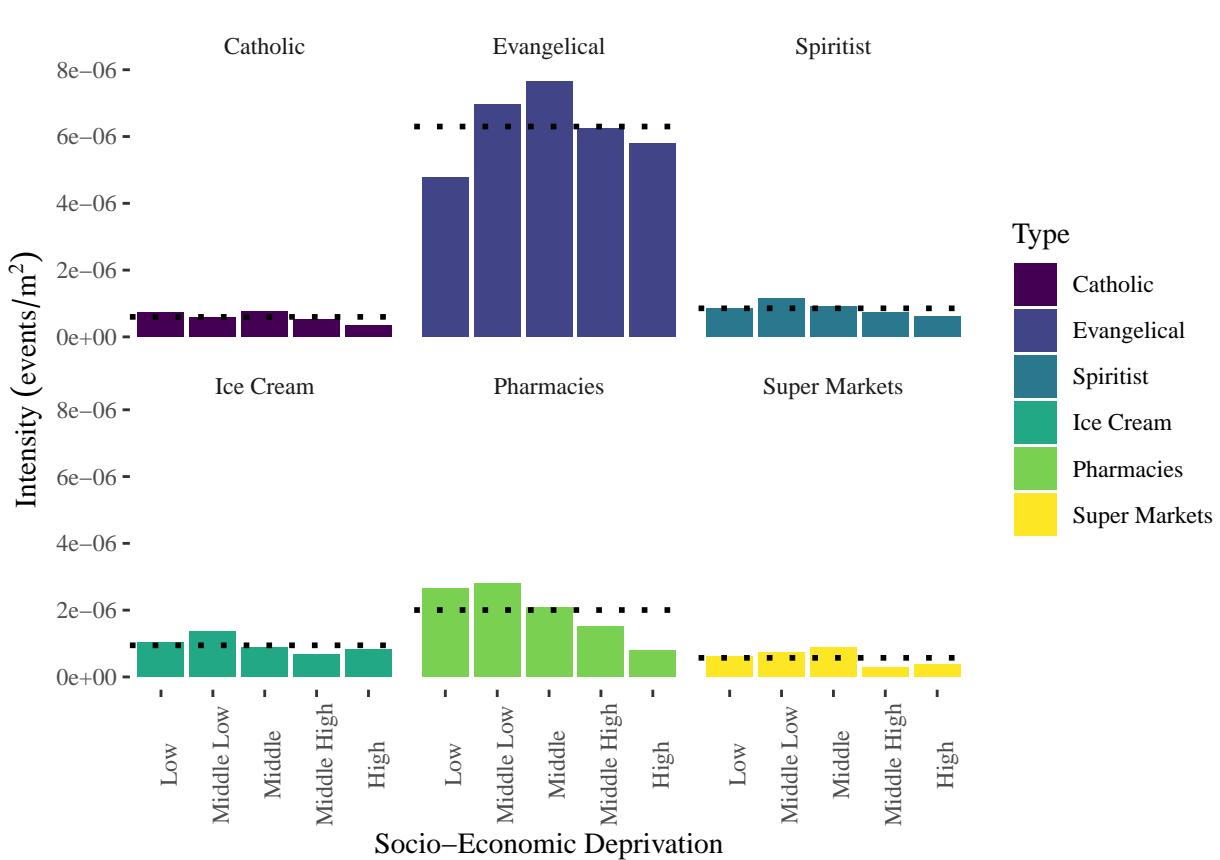


Fig. 6 Intensity of places of worship and commercial establishments by level of Socio-Economic Deprivation; the dotted lines indicates the respective global intensities

Table 4 χ^2 tests of independence of conditional quadrat counts

Event	Statistic	Degrees of Freedom	p-value
Catholic	7.074	4	0.264
Evangelical	32.976	4	< 0.001
Spiritist	7.561	4	0.2181
Ice Cream Shop	13.946	4	0.0149
Pharmacy	53.220	4	< 0.001
Supermarket	18.819	4	0.0017

1 5.3 Relative Distribution
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The preceding analysis provides a valuable backdrop. As seen there, there is a clear distribution of criminal events, increasing on par with the level of Socio-Economic deprivation. Of the three different classes of places of worship, only Evangelical churches display a locational pattern that is commensurate, with Socio-Economic Deprivation, albeit the pattern is distinct from criminal events, with Evangelical churches found less frequently in both high and low Socio-Economic Deprivation areas.

The analysis does not answer the question, yet, of possible covariations between crime, on the one hand, and places of worship and commercial establishments, on the other. In this subsection we implement the relative distribution estimator of intensity of Lethal and Intentional Violent Crime. The covariate $Z(u)$ in this analysis is distance to one of a place of worship or a commercial establishment:

$$\lambda_k(s) = \rho(Z_k(s))$$

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with:

$$Z_k(s) = d_{sk}$$

In the expression above, d_{sk} is distance from location s to an event of class k , and $k = \{\text{Catholic, Evangelical, Spiritist, Ice Cream Shop, Pharmacy, Supermarket}\}$.

The results of this analysis are shown in Figure 7. The global estimator for the intensity of crime is shown in this figure as a dotted line. Three types of places of worship are shown in solid lines, and three types of commercial establishments are shown in dashed lines. Each relative distribution function is shown with its corresponding 95% confidence bands.

Several interesting things emerge from inspection of this figure. First, we notice that with the exception of Spiritist churches (which has an intensity significantly lower than the global intensity at a distance of zero), the intensity of crime at for other churches and commercial establishments is close, but higher than, the global intensity of crime. In general, the intensity tends to increase at short distances; however, this effect is much more marked for Evangelical places of worship. The intensity of crime in the proximity of these places of worship grows rapidly within a short distance, reaching a peak of 2.4916×10^{-5} at a distance of 64.92 m. At that distance, the intensity of crime with respect to Evangelical places of worship is 183.78% higher than the intensity of Catholic places of worship; 194.54% higher than the intensity of crime with respect to Spiritist churches; 174.19% higher than the intensity with respect to ice cream shops; 151.52% higher than the intensity with respect to pharmacies; and 177.63% higher than the intensity with respect to supermarkets.

Intriguingly, after reaching its peak intensity, the intensity of crime with respect to Evangelical places of worship declines sharply, until at distances of approximately 200 m it is lower than for other places of worship and commercial establishments, and at distances of approximately 270 m it is lower than

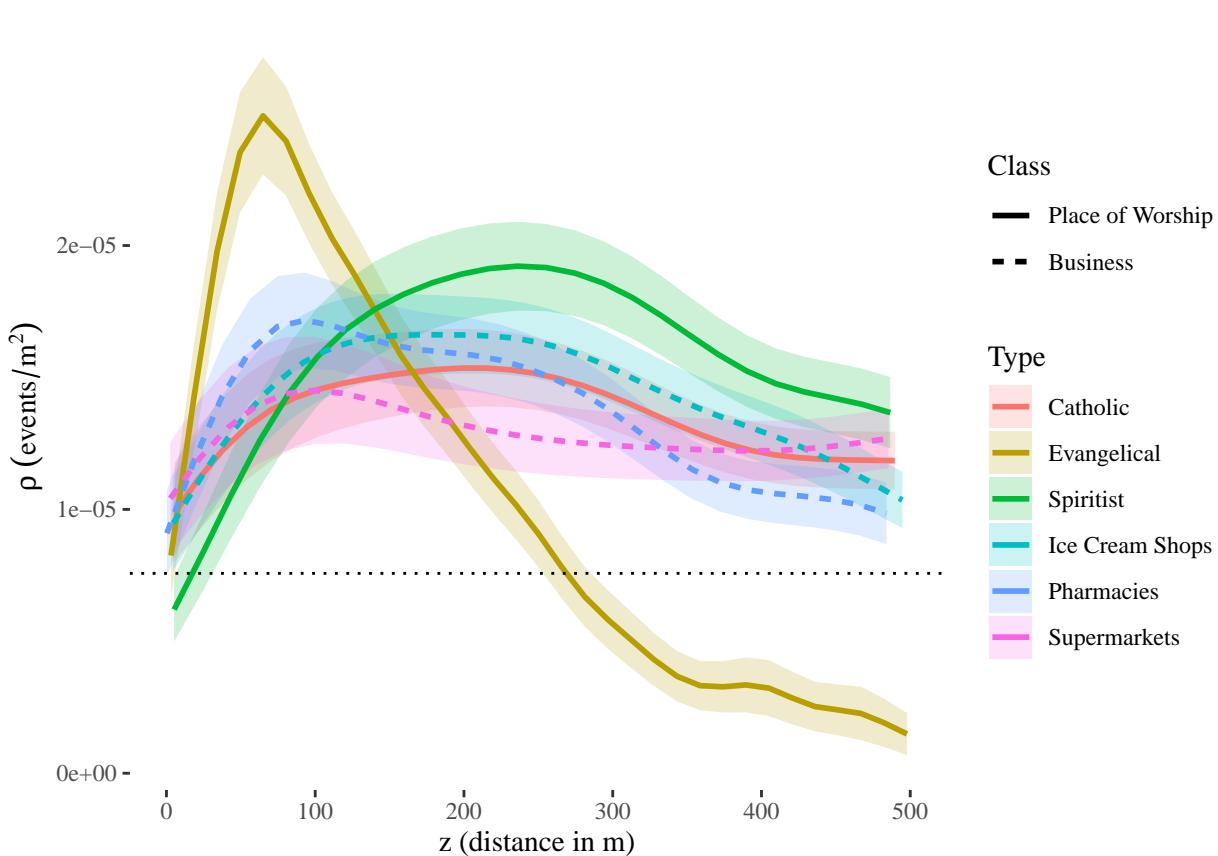


Fig. 7 Intensity of crime as a function of distance to a selected place of worship or commercial establishment; bands are 95% confidence interval and the dotted line indicates the global intensity of crime

the global intensity of crime. This does not happen with other places of worship or commercial establishments: the intensity of crime with respect to these locations remains higher than the global intensity of crime for the interval of distances examined. Another interesting observation is that the intensity of crime with respect to Catholic places of worship is not substantially different when compared to the intensity of crime with respect to any of the commercial establishments considered.

These results, while intriguing, beg the question of whether variations in Socio-Economic Deprivation may have a confounding effect on the relative distributions; for instance, if as seen in the case of conditional quadrat counts, there is some overlap in the locational patterns of, say, Evangelical places of worship and crime with respect to Socio-Economic Deprivation. Next section explores this question.

1 5.4 Relative Distribution with a Baseline Function
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In this section, the preceding analysis regarding the relative distribution of crime using distance to places of worship and commercial establishments is repeated, after introducing a baseline function. The interpretation of $\rho(Z(s))$ in this case is as follows: instead of the raw intensity at the value of z , it is the intensity *relative to the intensity according to the level of Socio-Economic Deprivation*. Therefore, $\rho(z) = 1$ matches the intensity according to Socio-Economic Deprivation; values of $\rho(z) > 1$ indicate a higher intensity than explained by Socio-Economic Deprivation; and values of $\rho(z) < 1$ correspond to lower intensities than explained by Socio-Economic Deprivation.

The results of the analysis are shown in Figure 8. The general trends shown by the relative distribution functions are similar to those seen above, before the introduction of a baseline function. We notice that at short distances the intensity of crime as a function of distance to the various places of worship and commercial establishments is higher than the baseline intensity (i.e., the intensity according to Socio-Economic Deprivation). The only exception is intensity as a function of distance to a Spiritist church, which at short distances is not significantly different from the baseline intensity (see the confidence bands).

The peak intensity as a function of distance to Evangelical churches is 3.32 times the baseline intensity; for Catholic places of worship, the highest intensity is 2.12 times the baseline intensity; and the intensity reaches a peak of 2.67 times the baseline intensity when the covariate is distance to Spiritist churches. Turning now to inspect the three types of commercial establishments, we see that the highest intensities are 2.28, 2.45, and 2.09 times the intensity according to Socio-Economic Deprivation for ice cream shops, pharmacies, and supermarkets, respectively.

Some differences are observed as well. Whereas the peak intensity as a function of distance to Evangelical places of worship was 183.78% higher than the intensity of Catholic places of worship *without a baseline function*, once that we account for Socio-Economic Deprivation by means of a baseline function, the peak relative intensity as a function of distance to Evangelical churches declines to 176.48% higher than the intensity as a function of distance to Catholic places of worship at the same distance. Accounting for Socio-Economic Deprivation in this analysis of intensity has in general a moderating effect: whereas the peak intensity of crime was 194.54% higher when comparing Evangelical and Spiritist churches at the distance of the peak intensity of Evangelical churches, this difference declines to 186.43% after accounting for Socio-Economic Deprivation. Similarly, this changes from 174.19% to 168.37% in the case of ice cream shops, from 151.52% to 140.98% in the case of pharmacies, and finally from 177.63% to 164.31% in the case of supermarkets.

Again, it is interesting to note that while the intensity with respect to distance to Catholic and Spiritist places of worship, as well as ice cream shops, pharmacies, and supermarkets remains higher than the background intensity (given by the baseline according to Socio-Economic Deprivation), the intensity

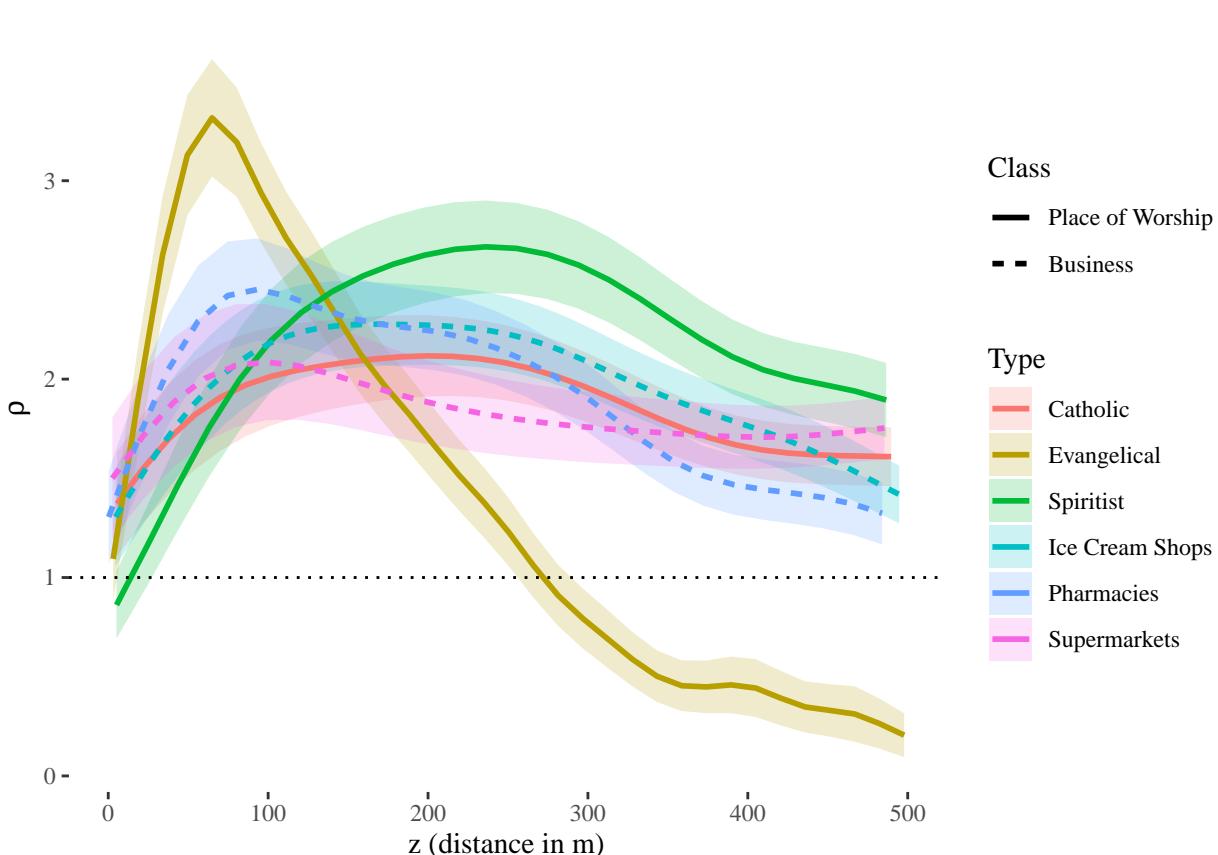


Fig. 8 Intensity of crime as a function of distance to a selected place of worship or commercial establishment after introducing Socio-Economic Deprivation as a baseline function; bands are 95% confidence intervals and the dotted line indicates the baseline intensity with respect to Socio-Economic Deprivation

of crime at distances of approximately 300 m of an Evangelical church are significantly lower than the background intensity of crime. In the following section we discuss the possible implications of these findings.

6 Discussion

Theories of moral communities and social disorganization suggest that the presence of institutions that can provide a measure of social control can help to improve crime prevention, and this has been borne to some extent by previous empirical research. However, as noted by Warner and Konkel (2019), it is important to distinguish between different religious traditions.

In this respect, it has been argued that Catholics and some Protestant groups are more adept at generating bridging social capital with strong inter-group relations. This can result in greater collective efficacy - which in turn can decrease the likelihood of crime (see Hoffmann 2015, 2). Along these lines, Beyerlein and Hipp (2005), examined data for 3,157 counties in the United States in 2000, and found that counties with greater percentages of people affiliated with mainline Protestant and Catholic traditions tended to have lower crime rates. Similarly, Warner and Konkel (2019) found that mainline Protestant and bridging churches (but not Catholic churches) correlated positively with informal social control at the neighborhood level in two cities in Kentucky. Nie and Yang (2019), in a study of smoking, also found that share of Catholic population in counties did not reduce the rate of smoking, thus bringing into question the efficacy of this type of moral community in generating social control - albeit at a fairly aggregated scale (counties). Our findings with respect to Catholic places of worship echo these results at a much higher level of disaggregation, as we fail to find evidence that Catholic churches project a moral community in space more than any of various common types of business establishments.

Conservative Protestant and Evangelic traditions, unlike mainline Protestants and Catholics, appear to focus less on bridging and more on bonding social capital with strong within-group relations. Associated with this, Conservative Protestant doctrine emphasizes individual responsibility, and therefore social ills tend to be seen as primarily personal ills in need of religious redemption instead of secular interventions (Nie and Yang 2019, 2–3). Under this light, a moral community with such views of social problems may not be effective to deter crime (Ellison, Burr, and McCall 2003); instead, conservative Protestant doctrine may be more tolerant of violent behavior when associated with defense of honor, family, property, or women, or unfortunate events may be seen as representing legitimate celestial retribution for moral turpitude. Empirical research by Beyerlein and Hipp (2005) found that counties with greater percentages of people affiliated with Evangelical traditions tended to have higher crime rates. More recent research by Desmond et al. (2010) in more than 400 block groups in Indianapolis found that neighborhoods with a greater presence of Evangelical congregations had higher rates of both violent and property crimes. In the specific context of Brazil, it is important to consider the role that religion has had in interpreting and conferring meaning to urban violence, or what Brazilian anthropologist Patricia Birman has termed “The Violence of the Just” (see Birman and Machado 2012; Birman 2019).

Our analysis suggests that the role of Evangelical churches may be more complex than thought: on the one hand, our results indicate that Lethal and Intentional Violent Crime tends to be more intense in the proximity of Evangelical places of worship, up to a distance of approximately 100 m, but then declines even below the global intensity and the background intensity at distances between 300 m and 100 m. It is at the moment unclear what could cause this, and candidate explanations could include the way police respond to crime incidents in different neighborhoods, the likelihood of residents reporting crime

1 to the police, and the level of opportunity for crimes (Warner and Konkel
2 2019). Could Evangelicals churches provide greater levels of opportunity for
3 crime, if adherents to this tradition are seen as meek? And is it possible that
4 at a different scale, unlike reports by other researchers, Evangelical churches
5 are more effective at keeping social control? While these speculations cannot
6 be answered in the context of the present study, we suggest that these might
7 be fruitful areas for future research.
8

9 Finally, we would like to remark on the results regarding Spiritist churches,
10 which in some way are the mirror image of those for Evangelical churches.
11 An extensive scan of the literature finds much less information about this
12 religious tradition, in particular in the context of Brazil where it adapted
13 in ways that made it very different from its original French predecessor (see
14 Arribas 2011b). Could it be that Spiritism is seen by potential criminals as
15 spiritually or materially risky, if supernatural retribution is feared? Again, we
16 cannot do more than speculate about this at the moment, but this might be
17 another worthwhile avenue for future investigation.
18

19 20 21 7 Conclusions

22 The objective of this research was to investigate the covariation of incidence of
23 crime to proximity of places of worship. The hypothesis of moral communities
24 (closely related to social informal controls) posits a negative correlation be-
25 tween the presence of churches and crime. Recent papers have argued that it is
26 important to study this phenomenon from a geographical perspective, paying
27 attention to the level of aggregation. Accordingly, our research for the city of
28 Recife in Brazil makes the following contributions to the literature:
29

- 30 1. By using disaggregated data for Lethal and Intentional Violent Crime and
31 various types of places of worship, we were able to analyze the intensity of
32 crime with respect to proximity to churches as a point pattern.
- 33 2. Following the suggestion of Warner and Konkel (2019), we also disaggre-
34 gated our data by type of place of worship, and considered the three fol-
35 lowing denominations: Catholic, Evangelical, and Spiritist.
- 36 3. We used relative distribution functions, a multi-scale technique, that al-
37 lowed us to estimate the intensity of crime at different distances from var-
38 ious types of places of worship.
- 39 4. We also used a set of putatively morally neutral commercial establish-
40 ments to serve as controls in our analysis.

41 Our key findings can be summarized as follows:

- 42 1. Catholic places of worship do not seem to geographically project more or
43 less of a moral community effect than, say, ice cream shops, pharmacies, or
44 supermarkets: the intensity of crime as a function of distance to Catholic
45 churches is not significantly different than what we observe when we con-
46 sider distance to any of these types of commercial establishments, at any
47 distance.
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2. The intensity of crime with respect to distance to Evangelical churches is more complex than previously known: whereas the intensity of crime is higher at relatively short distance from Evangelical places of worship, at longer distances it tends to decline even below the global intensity of crime and the background level of crime according to Socio-Economic Deprivation.
3. Spiritist churches are associated with lower intensity of crime at very short distance; however, at longer distances (approximately between 200 m and 500 m), the intensity of crime is in fact higher than the intensity of crime at comparable distances from Catholic and Evangelical places of worship, or any of the three kinds of commercial establishments.

These results are interesting in and of themselves as they help to clarify the potential of various types of moral communities to act as restraints on crime or, on the contrary, as criminogenic factors. They also suggest several recommendations.

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1. The analysis presented in this paper is to a large extent exploratory. For example, to introduce a baseline function in the analysis of relative distribution, we used a data reduction technique to obtain an indicator of Socio-Economic Deprivation. This indicator was useful to determine a general spatial pattern of crime conditional on this variable, and to account for a baseline (or background) intensity of crime. However, it would be interesting to investigate the effect of the individual socio-economic and demographic variables on the intensity of crime, as opposed to the aggregated effect of Socio-Economic Deprivation. This implies the use of multivariate analytical techniques.
2. It would be interesting to explore the effect of aggregation on the results. On the one hand, this would be informative with respect to the well-known issues with aggregation bias in spatial analysis (related to the Modifiable Areal Unit Problem in geography; see Fotheringham and Wong 1991; Openshaw and Taylor 1979; and Tagashira and Okabe 2002). On the other hand, as the results of the research presented here, it is possible that analysis at different levels of aggregation may tend to capture different spatial and social processes of interest.
3. And finally, in relation to the latter point, more in-depth research, perhaps observational, ethnographic, or participatory studies, could help to develop a more refined understanding of the kinds of processes that operate at different scales and how they can influence moral behavior and crime. For example, an important question is whether the higher intensity of crime in the neighborhood of Evangelical churches is related to “The Violence of the Just” (see Birman and Machado 2012; Birman 2019), or contrariwise, crime committed *against* Evangelical Christians as a result of religious intolerance (see Souza 2019; Fonseca 2018).

In summary, the research presented on this paper provides information about the potential of different types of moral communities to reduce crime,

and should be of interest to policy makers as they assess whether formal or informal forms of social control can be effective to deter criminal behavior, in order to achieve development goals.

8 Acknowledgments

The following R packages were used in the course of this investigation and the authors wish to acknowledge their developers: **faterize** (Ross 2018), **ggthemes** (Arnold 2018), **kableExtra** (Zhu 2018), **knitr** (Xie 2015, 2018), **maptools** (Bivand and Lewin-Koh 2019), **spatstat** (Baddeley and Turner 2005), **raster** (Hijmans 2018), **rticles** (Allaire et al. 2018), **sf** (Pebesma 2018), and **tidyverse** (Wickham 2017).

References

- Abdullah, Snhs, F. A. Bohani, Z. A. Nazri, Y. Jeffry, M. A. Abdullah, M. N. Junoh, and Z. A. Kasim. 2018. "Amenities Surrounding Commercial Serial Crime Prediction at Greater Valley and Kuala Lumpur Using K-Means Clustering." Journal Article. *Jurnal Teknologi* 80 (4): 43–53. %3CGo%20to%20ISI%3E://WOS:000437011000005.
- Allaire, JJ, Yihui Xie, R Foundation, Hadley Wickham, Journal of Statistical Software, Ramnath Vaidyanathan, Association for Computing Machinery, et al. 2018. *Rticles: Article Formats for R Markdown*. <https://CRAN.R-project.org/package=rticles>.
- Appleyard, D. 1980. "Livable Streets - Protected Neighborhoods." Journal Article. *Annals of the American Academy of Political and Social Science* 451 (SEP): 106–17. %3CGo%20to%20ISI%3E://A1980KK14700011.
- Arnold, Jeffrey B. 2018. *Ggthemes: Extra Themes, Scales and Geoms for 'Ggplot2'*. <https://CRAN.R-project.org/package=ggthemes>.
- Arribas, Celia da Graca. 2011a. "A Doutrina Espírita Na Formação Da Diversidade Religiosa Brasileira." *Anais Do XXVI Simpósio Nacional de História - ANPUH, São Paulo*.
- . 2011b. "Espiritismo: Entre Crime E Religiao." *Mneme-Revista de Humanidades* 12 (29).
- Baddeley, Adrian, Ege Rubak, and Rolf Turner. 2015. *Spatial Point Patterns: Methodology and Applications with R*. Book. Chapman; Hall/CRC.
- Baddeley, Adrian, and Rolf Turner. 2005. "spatstat: An R Package for Analyzing Spatial Point Patterns." *Journal of Statistical Software* 12 (6): 1–42. <http://www.jstatsoft.org/v12/i06/>.
- Bailey, T. C., and A. C. Gatrell. 1995. *Interactive Spatial Data Analysis*. Book. Essex: Addison Wesley Longman.
- Becker, Kalinca Léia, and Ana Lúcia Kassouf. 2017. "Uma análise Do Efeito Dos Gastos Públicos Em Educação Sobre a Criminalidade No Brasil." *Economia E Sociedade* 26 (1): 215–42.

- 1 Beyerlein, Kraig, and John R Hipp. 2005. "Social Capital, Too Much of a
2 Good Thing? American Religious Traditions and Community Crime." Journal
3 Article. *Social Forces* 84 (2): 995–1013.
- 4 Birman, Patricia, and Carly Machado. 2012. "A Violencia Dos Justos:
5 Evangelicos, Midia E Periferias Da Metropole." *Revista Brasileira de Ciências
6 Sociais* 27 (80): 55–69.
- 7 Birman, Patricia. 2019. "NARRATIVAS Seculares E Religiosas Sobre a
8 Violencia: AS Fronteiras Do Humano No Governo Dos Pobres." *Sociologia &
9 Antropologia* 9 (1).
- 10 Bivand, Roger, and Nicholas Lewin-Koh. 2019. *Maptools: Tools for Hand-
11 ling Spatial Objects*. <https://CRAN.R-project.org/package=maptools>.
- 12 Brower, A. M., and L. Carroll. 2007. "Spatial and Temporal Aspects of
13 Alcohol-Related Crime in a College Town." Journal Article. *Journal of Amer-
14 ican College Health* 55 (5): 267–75. <https://doi.org/10.3200/jach.55.5.267-276>.
- 15 Chesnut, R Andrew. 2017. *Devoted to Death: Santa Muerte, the Skeleton
16 Saint*. Oxford University Press.
- 17 Craglia, M., R. Haining, and P. Wiles. 2000. "A Comparative Evaluation of
18 Approaches to Urban Crime Pattern Analysis." Journal Article. *Urban Studies*
19 37 (4): 711–29. ISI:000086520800005.
- 20 Davignon, P., and R. A. Thomson. 2015. "Christian Colleges and Univer-
21 sities as Moral Communities: The Effects of Institutional Characteristics on
22 Student Religiosity." Journal Article. *Review of Religious Research* 57 (4):
23 531–54. <https://doi.org/10.1007/s13644-015-0214-5>.
- 24 Deryol, R., P. Wilcox, M. Logan, and J. Wooldredge. 2016. "Crime Places
25 in Context: An Illustration of the Multilevel Nature of Hot Spot Development."
26 Journal Article. *Journal of Quantitative Criminology* 32 (2): 305–25. <https://doi.org/10.1007/s10940-015-9278-1>.
- 27 Desmond, S. A., G. Kikuchi, and K. H. Morgan. 2010. "Congregations and
28 Crime: Is the Spatial Distribution of Congregations Associated with Neighbor-
29 hood Crime Rates?" Journal Article. *Journal for the Scientific Study of Reli-
30 gion* 49 (1): 37–55. <https://doi.org/10.1111/j.1468-5906.2009.01491.x>.
- 31 Donovan, Peter. 1986. "Do Different Religions Share Moral Common Ground?"
32 Journal Article. *Religious Studies* 22 (3/4): 367–75. <http://www.jstor.org.libaccess.lib.mcmaster.ca/stable/20006295>.
- 33 Doran, Bruce J, and Melissa B Burgess. 2011. *Putting Fear of Crime on
34 the Map: Investigating Perceptions of Crime Using Geographic Information
35 Systems*. Springer Science & Business Media.
- 36 Durrant, Russil, and Zoe Poppelwell. 2017. "Why Religion Matters." In
37 *Religion, Crime and Punishment*, 1–17. Springer.
- 38 Eitle, D. 2011. "Religion and Gambling Among Young Adults in the United
39 States: Moral Communities and the Deterrence Hypothesis." Journal Article.
40 *Journal for the Scientific Study of Religion* 50 (1): 61–81. <https://doi.org/10.1111/j.1468-5906.2010.01552.x>.
- 41
- 42
- 43
- 44
- 45
- 46
- 47
- 48
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- 52
- 53
- 54
- 55
- 56
- 57
- 58
- 59
- 60
- 61
- 62
- 63
- 64
- 65

- 1 Ellison, Christopher G, Jeffrey A Burr, and Patricia L McCall. 2003. "The
2 Enduring Puzzle of Southern Homicide: Is Regional Religious Culture the
3 Missing Piece?" *Homicide Studies* 7 (4): 326–52.
4 Feitosa, F. F., G. Camara, A. M. V. Monteiro, T. Koschitzki, and M. P. S.
5 Silva. 2007. "Global and Local Spatial Indices of Urban Segregation." Journal
6 Article. *International Journal of Geographical Information Science* 21 (3):
7 299–323. ISI:000244944300004%0AC:/Papers/International%20Journal%20of%
8 20Geographical%20Information%20Science/IJGIS%20(2007)%2021%20(3)%20299-
9 323.pdf.
10 Fonseca, Alexandre Brasil. 2018. "Primeiras Análises Dos Dados Do Re-
11 latório Sobre Intolerância E Violência Religiosa No Brasil (2011-2015)." Journal
12 Article. *Estado Laico, Intolerância E Diversidade Religiosa No Brasil.*
13 *Brasília, Ministério Dos Direitos Humanos*, 22–47.
14 Foster, S., B. Giles-Corti, and M. Knuiman. 2010. "Neighbourhood Design
15 and Fear of Crime: A Social-Ecological Examination of the Correlates of Resi-
16 dents' Fear in New Suburban Housing Developments." Journal Article. *Health*
17 & Place 16 (6): 1156–65. <https://doi.org/10.1016/j.healthplace.2010.07.007>.
18 Fotheringham, A. S., and D. W. S. Wong. 1991. "The Modifiable Areal Unit
19 Problem in Multivariate Statistical-Analysis." Journal Article. *Environment*
20 and Planning A 23 (7): 1025–44. ISI:A1991GA61200008.
21 Furr-Holden, C. D. M., K. D. M. Campbell, A. J. Milam, M. J. Smart,
22 N. A. Ialongo, and P. J. Leaf. 2010. "Metric Properties of the Neighbor-
23 hood Inventory for Environmental Typology (Nifety): An Environmental As-
24 sessment Tool for Measuring Indicators of Violence, Alcohol, Tobacco, and
25 Other Drug Exposures." Journal Article. *Evaluation Review* 34 (3): 159–84.
26 <https://doi.org/10.1177/0193841x10368493>.
27 Garmany, J. 2014. "Space for the State? Police, Violence, and Urban
28 Poverty in Brazil." Journal Article. *Annals of the Association of American*
29 *Geographers* 104 (6): 1239–55. <https://doi.org/10.1080/00045608.2014.944456>.
30 Gilbertson, Alan, and Alan Hayes. 2012. "Engineering to Reduce Crime
31 and Disorder in Public Places." In *Proceedings of the Institution of Civil*
32 *Engineers-Municipal Engineer*, 165:175–83. 3. Thomas Telford Ltd.
33 Grannis, R. 2009. *From the Ground up: Translating Geography into Com-
34 munity Through Neighbor Networks*. Book. Princeton: Princeton University
35 Press.
36 Groff, E. R. 2015. "Informal Social Control and Crime Events." Journal
37 Article. *Journal of Contemporary Criminal Justice* 31 (1): 90–106. <https://doi.org/10.1177/1043986214552619>.
38 He, Li, Antonio Páez, and Desheng Liu. 2017. "Built Environment and Vi-
39 olent Crime: An Environmental Audit Approach Using Google Street View."
40 Journal Article. *Computers, Environment and Urban Systems* 66: 83–95. <https://doi.org/http://dx.doi.org/10.1016/j.compenvurbsys.2017.08.001>.
41 He, L., A. Paez, D. S. Liu, and S. G. Jiang. 2015. "Temporal Stability
42 of Model Parameters in Crime Rate Analysis: An Empirical Examination."
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

- 1 Journal Article. *Applied Geography* 58: 141–52. <https://doi.org/10.1016/j.apgeog.2015.02.002>.
- 2 Hijmans, Robert J. 2018. *Raster: Geographic Data Analysis and Modeling*.
3 <https://CRAN.R-project.org/package=raster>.
- 4 Hipp, J. R. 2007. “Block, Tract, and Levels of Aggregation: Neighborhood
5 Structure and Crime and Disorder as a Case in Point.” Journal Article.
6 *American Sociological Review* 72 (5): 659–80. <https://doi.org/10.1177/0003122407200501>.
- 7 Hirschi, Travis, and Rodney Stark. 1969. “Hellfire and Delinquency.” *Social
8 Problems* 17 (2): 202–13.
- 9 Hoffmann, John P. 2015. “Religion and Crime.” *The Encyclopedia of Crime
10 and Punishment*, 1–5.
- 11 Ichihara, M. Y. T., D. Ramos, P. Reboucas, F. J. Oliveira, A. J. F. Ferreira,
12 C. Teixeira, M. Allik, et al. 2018. “Area Deprivation Measures Used in Brazil:
13 A Scoping Review.” Journal Article. *Revista de Saude Publica* 52 (83): 1–14.
14 <https://doi.org/10.11606/s1518-8787.2018052000933>.
- 15 Jacobs, Jane. 1961. *The Death and Life of Great American Cities*. Book.
16 New York: Vintage.
- 17 ———. 1968. “Community on the City Streets.” Book Section. In *The
18 Search for Community in Modern America*, edited by D. Baltzell, 74–93. New
19 York: Harper & Row.
- 20 Johnson, Byron. 2011. *More God, Less Crime: Why Faith Matters and How
21 It Could Matter More*. Templeton Foundation Press.
- 22 Kiani, Rasoul, Siamak Mahdavi, and Amin Keshavarzi. 2015. “Analysis and
23 Prediction of Crimes by Clustering and Classification.” *International Journal
24 of Advanced Research in Artificial Intelligence* 4 (8): 11–17.
- 25 Lee, M. R., and J. P. Bartkowiak. 2004. “Love Thy Neighbor? Moral Com-
26 munities, Civic Engagement, and Juvenile Homicide in Rural Areas.” Journal
27 Article. *Social Forces* 82 (3): 1001–35. <https://doi.org/10.1353/sof.2004.0044>.
- 28 Levine, Ned, Martin Wachs, and Elham Shirazi. 1986. “Crime at Bus Stops:
29 A Study of Environmental Factors.” *Journal of Architectural and Planning
30 Research*, 339–61.
- 31 Lipton, R., A. Banerjee, D. Levy, N. Manzanilla, and M. Cochrane. 2008.
32 “The Spatial Distribution of Underage Tobacco Sales in Los Angeles.” Journal Article.
33 *Substance Use & Misuse* 43 (11): 1597–1617. <https://doi.org/10.1080/10826080802241110>.
- 34 Loukaitou-Sideris, A., R. Liggett, H. Iseki, and W. Thurlow. 2001. “Mea-
35 suring the Effects of Built Environment on Bus Stop Crime.” Journal Article.
36 *Environment and Planning B-Planning & Design* 28 (2): 255–80. <https://doi.org/10.1068/b2642r>.
- 37 Malleson, Nick, and Martin A Andresen. 2015. “Spatio-Temporal Crime
38 Hotspots and the Ambient Population.” *Crime Science* 4 (1): 10.
- 39 Malleson, N., W. Steenbeek, and M. A. Andresen. 2019. “Identifying the
40 Appropriate Spatial Resolution for the Analysis of Crime Patterns.” Journal Article.
41 *Plos One* 14 (6). <https://doi.org/10.1371/journal.pone.0218324>.

- 1 Menezes, T., R. Silveira-Neto, C. Monteiro, and J. L. Ratton. 2013. "Spatial
2 Correlation Between Homicide Rates and Inequality: Evidence from Urban
3 Neighborhoods." Journal Article. *Economics Letters* 120 (1): 97–99. <https://doi.org/10.1016/j.econlet.2013.03.040>.
- 4 Mora, G. Cristina. 2008. "Marketing the 'Health and Wealth Gospel' Across
5 National Borders; Evidence from Brazil and the United States." *Poetics* 36
6 (5): 404–20. <https://doi.org/https://doi.org/10.1016/j.poetic.2008.06.008>.
- 7 Murray, J., D. R. D. Cerqueira, and T. Kahn. 2013. "Crime and Violence in Brazil: Systematic Review of Time Trends, Prevalence Rates and
8 Risk Factors." Journal Article. *Aggression and Violent Behavior* 18 (5): 471–
9 83. <https://doi.org/10.1016/j.avb.2013.07.003>.
- 10 Nakaya, T., and K. J. Yano. 2010. "Visualising Crime Clusters in a Space-
11 Time Cube: An Exploratory Data-Analysis Approach Using Space-Time Kernel
12 Density Estimation and Scan Statistics." Journal Article. *Transactions in
13 Gis* 14 (3): 223–39. <https://doi.org/10.1111/j.1467-9671.2010.01194.x>.
- 14 Nie, F. H., and X. Z. Y. Yang. 2019. "Smoking in the Temple of the Holy
15 Spirit? Geographic Location Matters." Journal Article. *Health & Place* 58.
16 <https://doi.org/10.1016/j.healthplace.2019.05.017>.
- 17 Openshaw, S., and P. J. Taylor. 1979. "A Million or so Correlation Coefficients:
18 Three Experiments on the Modifiable Areal Unit Problem." Book Section.
19 In *Statistical Applications in the Spatial Sciences*, edited by N. Wrigley,
20 127–44. London: Pion.
- 21 Paez, A. 2013. "Mapping Travelers' Attitudes: Does Space Matter?" Journal
22 Article. *Journal of Transport Geography* 26: 117–25. <https://doi.org/10.1016/j.jtrangeo.2012.09.002>.
- 23 Pebesma, Edzer. 2018. "Simple Features for R: Standardized Support for
24 Spatial Vector Data." *The R Journal* 10 (1): 439–46. <https://doi.org/10.32614/RJ-2018-009>.
- 25 Quick, M., J. Law, and H. Luan. 2017. "The Influence of on-Premise and
26 Off-Premise Alcohol Outlets on Reported Violent Crime in the Region of Waterloo,
27 Ontario: Applying Bayesian Spatial Modeling to Inform Land Use Planning and Policy." Journal Article. *Applied Spatial Analysis and Policy* 10 (3):
28 435–54. <https://doi.org/10.1007/s12061-016-9191-5>.
- 29 Regnerus, M. D. 2003. "Moral Communities and Adolescent Delinquency:
30 Religious Contexts and Community Social Control." Journal Article. *Sociological
31 Quarterly* 44 (4): 523–54. %3CGo%20to%20ISI%3E://WOS:000188319800001.
- 32 Reiss, Albert J. 1951. "Delinquency as the Failure of Personal and Social
33 Controls." Journal Article. *American Sociological Review* 16 (2): 196–207.
34 <https://doi.org/10.2307/2087693>.
- 35 Ripley, B. D. 1976. "The Second-Order Analysis of Stationary Point
36 Processes." Journal Article. *Journal of Applied Probability* 13 (2): 255–66. ISI:
37 A1976CA37400007.
- 38
- 39
- 40
- 41
- 42
- 43
- 44
- 45
- 46
- 47
- 48
- 49
- 50
- 51
- 52
- 53
- 54
- 55
- 56
- 57
- 58
- 59
- 60
- 61
- 62
- 63
- 64
- 65

- 1 Rogerson, Peter, and Y Sun. 2001. "Spatial Monitoring of Geographic Patterns: An Application to Crime Analysis." *Computers, Environment and Urban Systems* 25 (6): 539–56.
- 2 Rohrbaugh, John, and Richard Jessor. 1975. "Religiosity in Youth: A Personal Control Against Deviant Behavior." *Journal of Personality* 43 (1): 136–55.
- 3 Ross, Noam. 2018. *Fasterize: Fast Polygon to Raster Conversion*. <https://CRAN.R-project.org/package=fasterize>.
- 4 Souza, André Ricardo de. 2019. "Pluralidade Cristã E Algumas Questões Do Cenário Religioso Brasileiro." *Revista USP*, no. 120: 13–22.
- 5 Stark, R. 1996. "Religion as Context: Hellfire and Delinquency One More Time." Journal Article. *Sociology of Religion* 57 (2): 163–73. <https://doi.org/10.2307/3711948>.
- 6 Stroope, S., and J. O. Baker. 2018. "Whose Moral Community? Religiosity, Secularity, and Self-Rated Health Across Communal Religious Contexts." Journal Article. *Journal of Health and Social Behavior* 59 (2): 185–99. <https://doi.org/10.1177/0022146518755698>.
- 7 Tagashira, N., and A. Okabe. 2002. "The Modifiable Areal Unit Problem in a Regression Model Whose Independent Variable Is a Distance from a Predetermined Point." Journal Article. *Geographical Analysis* 34 (1): 1–20. ISI:000173383000001.
- 8 Taylor, Ralph B. 1988. *Human Territorial Functioning: An Empirical, Evolutionary Perspective on Individual and Small Group Territorial Cognitions, Behaviors, and Consequences*. Book. Cambridge University Press.
- 9 Taylor, Ralph B. 1998. "Crime and Small-Scale Places: What We Know, What We Can Prevent, and What Else We Need to Know." Book Section. In *Crime and Place: Plenary Papers of the 1997 Conference on Criminal Justice Research and Evaluation*, edited by Ralph B. Taylor, 1–22. Washington, D.C.: National Institute of Justice.
- 10 Topalli, V., T. Brezina, and M. Bernhardt. 2013. "With God on My Side: The Paradoxical Relationship Between Religious Belief and Criminality Among Hardcore Street Offenders." Journal Article. *Theoretical Criminology* 17 (1): 49–69. <https://doi.org/10.1177/1362480612463114>.
- 11 Traunmuller, R. 2011. "Moral Communities? Religion as a Source of Social Trust in a Multilevel Analysis of 97 German Regions." Journal Article. *European Sociological Review* 27 (3): 346–63. <https://doi.org/10.1093/esr/jcq011>.
- 12 United Nations Office on Drugs and Crime. 2019a. "Global Study on Homicide 2019: Executive Summary." UNODC Vienna.
- 13 ———. 2019b. "Global Study on Homicide 2019: Homicide, Development and the Sustainable Development Goals." UNODC Vienna.
- 14 Warner, B. D., and R. H. Konkel. 2019. "Neighborhood Churches and Their Relationship to Neighborhood Processes Important for Crime Prevention." Journal Article. *Journal of Urban Affairs*. <https://doi.org/10.1080/07352166.2019.1581030>.

-
- 1 Wickham, Hadley. 2017. *Tidyverse: Easily Install and Load the 'Tidyverse'*.
2 <https://CRAN.R-project.org/package=tidyverse>.
3
4 Xie, Yihui. 2015. *Dynamic Documents with R and Knitr*. 2nd ed. Boca
5 Raton, Florida: Chapman; Hall/CRC. <https://yihui.name/knitr/>.
6
7 ———. 2018. *Knitr: A General-Purpose Package for Dynamic Report Gen-*
8 *eration in R*. <https://yihui.name/knitr/>.
9 Zhu, Hao. 2018. *KableExtra: Construct Complex Table with 'Kable' and*
10 *Pipe Syntax*. <https://CRAN.R-project.org/package=kableExtra>.

Response to Reviewers

We would like to thank the editor and two anonymous reviewers for their thoughtful comments and suggestions to revise the paper. We believe that the paper has been substantially improved by their input. In this letter we respond to the feedback received, and describe the actions taken to revise the paper.

#Reviewer 1

This article uses spatial point pattern methods to explore the distribution of violent crime as it relates to the location of three types of churches and other land use types in Recife, Brazil. The authors suggest that the intensity of violent crimes is higher near to evangelical churches than other types of churches.

Thank you for reading the paper and for your thoughtful suggestions to improve it.

The article as currently written is lacking a thorough and logical argument as to why the location of churches can be hypothesized to influence violent crime at the point-level (i.e., where distance is the measure of interest rather than location within an area).

Thank you for this comment. We believe this question has two parts: can we hypothesize that the location of churches influences violent crime? And if so, does this influence happen at the point level?

We believe that the first question is critical: what are the theoretical arguments for the influence of places of worship on crime? We can sketch this argument in the following way:

1. Informal social controls can suppress crime by strengthening the capabilities of neighbors to control inappropriate behavior.
2. Several types of community organizations, including schools, clubs, and neighborhood associations, can strengthen the capabilities of communities to exert informal social control.
3. Of several types of community organizations, churches are among the most overtly moral, since they often have prescriptive codes of behavior.
4. Why would the location of places of worship matter? Groff (2015) reviews several theoretical perspectives that address the role of informal social control in micro-places: these include "eyes on the street" and human territorial functioning. By affecting informal surveillance, movement governing rules, direct intervention, and the social climate at places, places of worship are hypothesized to contribute to informal social controls.

We believe that this argument is logical and sound, and churches, in fact, have been studied in the past for their potential to suppress crime (Abdullah, 2018; Davignon, 2015; Furr, 2010; Traumuller, 2011). A more novel aspect is the study of places of worship, as distinct entities from the members of the congregations: as Warner and Konkel (2019) note, this is an aspect that has received less attention in empirical and theoretical research.

The second question is related to the above: if places of worship somehow help to strengthen social control, does this happen at the level of points or for areas? In our view, Groff (2015) already explains why these investigations should matter at the micro-level. But there is also an analytical aspect to this question: what is an appropriate unit of support for the analysis? In this sense, we would note that aggregating point data to areas inevitably involves loss of information. Sometimes this situation is unavoidable (say, statistics are recorded for areas, so locational information is lost from the origin.) But when we have access to detailed geographical information, converting to area data is an unnecessary loss of information. The question that we are asking is actually quite geographical: if there is evidence of a moral community effect, what is its distance decay? This question is best answered by considering the distance from criminal events to places of worship, instead of simple propinquity of criminal events and places of worship in areas.

We have edited the paper to increase its clarity.

The current framing of the article also does not convincingly situate 'moral communities' within a geographical framework and does not make clear the hypothesized mechanisms that link the presence/absence of a church at a specific location with criminal behavior and, more specifically, the presence/absence of churches of specific religions with violent crimes. The authors should make sure not to conflate the processes linking

crime with population characteristics (percent of individuals who are religious in an area), with religion more broadly (hellfire hypothesis), and with the location of a church in geographic space. This theoretical work is necessary to justify why this study is relevant and make clear how it contributes to the existing literature.

Thank you for this comment. As pointed out above, the theoretical work was discussed by Groff (2015), among others. Although conceptually the study draws from much earlier research (e.g., Appleyard, 1980; Jacobs, 1961, 1968; Taylor, 1988, 1998), empirical work has lagged, as recently noted by Warner and Konkel (2019). This is where the current paper aims to make a contribution.

The introduction of the paper does a really good job setting out the importance of reducing violent crime for achieving policy goals, but it is not clear how this research will contribute to developing, implementing, or evaluating policy. For this journal, I think it is necessary for the research to contribute to policy; so, how can police, religious officials, and other policymakers use the results of this study?

The analysis of elements that can influence the occurrence of the criminal act is able to increase the range of tools that public authorities can use to face the problem, particularly in a reality as difficult as that of Brazil. The notion of informal social control allows new strategies to combat crime to be explored. In particular, we find that Catholic churches do not "project" any more moral community than pharmacies, which means that there is probably not much that can be done in terms of leveraging them for informal social control purposes. Spiritist churches have a lower relative risk at relatively short distances of less than approximately 50 m (which would be the side of a small block). Why is this? We cannot posit a causality relationship, but could this be due to superstitious beliefs associated by laypeople to this religion? And if so, could this be leveraged for policy purposes? Evangelical churches, on the other hand, have a higher relative risk than any other establishment or place of worship at distance between 20-100 m. A relevant question is whether this is crime by Evangelicals or crime towards Evangelicals. This is not something that the analysis can throw light on, but that deserves further investigation to determine whether it can lead to actionable policy recommendations.

I currently find the logic of the analysis and the results to be confusing and I think that adding the results of more exploratory work before showing results of very specific analyses (i.e., those with SES quintiles and different church types) would help to provide a convincing argument that the results of this research are solid. For example, the authors may first examine the intensity of crime as it relates to all churches (aggregated), then to adjust for ses with all churches, and then to adjust for land use. Then, after presenting the results of the initial analysis for the aggregated churches, the results of the specific church types can be presented.

We hope that the revisions elsewhere (e.g., an improved presentation of the argument behind the analysis) have resolved this issue.

The authors should add a review of social disorganization theory and informal social control as these concepts are mentioned a number of times but not discussed in any detail. The similarities and differences between these concepts and the geographically-situated moral community concept should also be discussed.

The referee's suggestion has been incorporated into the text. Two footnotes have been included that detail theories of social disorganization and the theory of social control. The focus was to present the main characteristics of these theoretical views and to relate them to the geographical aspect. In general, both views highlight the relationship between local characteristics (neighborhoods, for example), social networks and criminal behavior.

The authors should justify their choice of method over other approaches, such as regression models, which provide a framework for quantifying the relationship between crime and churches after accounting for SES factors, land use types, and population at risk. There are a number of regression models that allow coefficients to vary over space, which would quantify how the impact of churches on crime changes by distance (see: generalized additive models, spatially-varying coefficients, geographically weighted regression). Without this type of analysis, or at least a more thorough discussion of why this point pattern method was chosen, I am not convinced that crime is, in fact, associated with evangelical churches at close distances and that this isn't due to other factors, like evangelical churches being located in high population density areas (and so crime is due to higher population density, not the presence of a church), for example.

Thank you for this comment. We agree, there are many methods that could be applied. In our analysis we use three tools:

1. Quadrat counts, which are discrete estimates of the intensity of a point process in a region.
1. The relative distribution, which is a smooth estimate of the intensity of a process as a function of distance to a signal event.
2. The relative distribution function with a baseline function, which adjusts the relative distribution using other risk factors. In our case, those other factors are summarized by the SED score. The interpretation of the relative distribution with a baseline is as follows: values of rho greater than 1 indicate that the intensity of crime is higher over what the baseline explains, and values less than 1 indicate that the intensity of crime is lower than what the baseline explains.

In the previous version of the paper, our SED score was calculated using several potential confounders of crime: median income, proportion of population unemployed, proportion of households with a single mother, proportion of households with a young single mother, proportion of population in poverty. In the current version of the paper, we also include population density in the calculation of the SED score (thank you for the suggestion). Accordingly, the relative distribution with a baseline function is the smooth estimate of the intensity of crime after controlling for potential confounders, including population density.

We believe that this approach is informative, and since we are interested in the distribution of crime in the proximity of places of worship, it is also appropriate. Furthermore, by considering other underlying risk factors (in the form of the SED score), we believe that we have diligently covered most reasonable confounders. We have edited the text to explain this.

Please define the term ‘neutral morality profile’ and how it relates to the spatial distribution of crime around land uses. Please also clarify what ‘having a spatial distribution commensurate with places of worship’ means and provide evidence to support this claim.

Following the referee suggestion, a footnote was added to the data section explaining clearly the highlighted terms. The idea of building a control group is to compare similar establishments about their spatial distribution, but different in relation to their neutrality profile in relation to crime, seeking to simulate the existence of a case and a control group.

Did this study investigate the location of crime events, offender locations, or victim locations? I assume crime events, but it would be good to clarify nonetheless.

In the data section, we changed the description. In the third paragraph, we use the term crime event location, which is more precise.

For the intensity measures, what is the unit area for the results? Would it be possible to provide an intensity unit such as per mile² or per km², for example? I think that this would improve the interpretation of the results and Figures 6 and 7 in particular.

Thank you for this comment. The intensity is in events/square meter, except in the case of the relative distribution with a baseline function, which is dimensionless (see below).

When discussing the quantitative results throughout Sections 5.3 and 5.4, please add uncertainty intervals so that readers can interpret the degree to which two quantities are, in fact, different? For example, p.16-line 49: “reaching a peak of 2.4916 * 10e-5 (95% CI: 2.1 * 10e-5, 3.2 * 10e-5).”

Thank you for this comment. The intervals of confidence are now reported in the figures.

Please provide some additional text describing the equations in Section 3.2. It is not immediately clear to me how to interpret equations and how they are reflected in the results. For example, what is B(s), how is it calculated, and what does it mean for understanding the distribution of crime in relation to churches?

Both quadrats and the relative distribution function are estimators of intensity. In the case of quadrats, the estimator is the number of events in the quadrat divided by area of the quadrat

(conditional quadrat counts use irregular quadrats that are defined based on some control variable, in our case SED). In the case of the relative distribution, the output is an estimate of intensity conditioned on distance from a signal event, i.e., a place of worship. The relative distribution can be adjusted by means of a baseline function $B(s)$, which is also an estimate of intensity but conditioned on some control covariate (in our cases SED). Therefore, the interpretation of the relative distribution with a baseline function is as a ratio of the intensity with respect to distance to the baseline intensity according to the control covariate. If the ratio, which is dimensionless, is 1, then intensity as a function of distance is equal to the baseline intensity.

For readers (like me) who are unfamiliar with the geography of Recife, Brazil, it would be helpful if a detailed map was included in the paper that shows where the downtown is, major roads, different neighborhoods, etc. This could be included in the background of Figure 1 or in an Appendix. It would also be helpful if the authors provided some description of the patterns observed in Figure 1 and Figure 2 identifying where violent crimes (or churches, supermarkets, etc.) were clustered and where they weren't clustered.

We now include a figure with maps for socio-economic and demographic variables which help to provide context to SED. We also have included a brief explanation of the requested clustering pattern in the text and recreated the figures after adding some transparency to compensate for overplotting. This should make it easier to appreciate the patterns.

How is the SES data, which I assume is distributed at the area-level, translated to points so it can be used in the point pattern analysis? Please describe how this was done and the limitations of doing so, if any. Related, why did the authors choose to break up SES into quintiles rather than keep it as a continuous measure or break up into other classifications?

Thank you for this comment. When using quadrats in the earlier part of the analysis, the region is partitioned using quintiles; this is a requirement, since quadrats function as "containers" and need to be partitioned in discrete segments. In Figure 4 each color is a "container". However, when calculating the distribution functions, the continuous value of the SED score is used. We have clarified this in the text.

What are the counts of the different types of churches, ice cream shops, pharmacies, and supermarkets? I am wondering if the frequency of each of these 'events' would influence the chi-square statistics and associated p-values shown in Table 3. Is this possible?

Thank you for this comment. The chi-square statistic is affected if there are small numbers if events in some quadrats, but that was not the case for any of our events. We have included a new table with the quadrat counts.

#Reviewer 2

This was an interesting paper to review, challenging even.

Thank you for reading the paper and for your thoughtful suggestions to improve it.

We'll start with a couple of minor issues

– in the quadrat analysis are the results conditioned on the quadrat size. If I understand correctly this might not be an issue with conditional quadrat counts, through the use of a covariate. It does remind me of Openshaw early work on optimal zoning systems. Perhaps a simple example to guide the reader might help.

The results are conditioned by the size of the quadrat, but in this case since the quadrats are defined based on a covariate, we have a conceptual reason to prefer them to other partitions (each quintile in the SED is one quadrat). We have explained in the text how the quadrats function as containers for counting events.

- the symbolism in Figure 1, 2, and 3 are rather large. I'm at a loss to interpret Figure 3, because as the image is built up (I have a rather slow graphics card) I see symbols overlapping.

Thank you for this comment. We have recreated the figures with some transparency to compensate for overplotting.

There's a cultural issue which I find challenging. I think I know what Catholic and Evangelical churches may be, but this is first encounter with Spiritism. I assume that the first two are differentiated along some transubstantiation/consubstantiation divide, with the Catholics being in the former group. As for Spiritist churches I'm at a loss. Do these follow the teaching of Allan Kardec; I presume it's related to the Spiritualist churches found in the Anglophone countries, which go back to Swedenborg and Mesmer, and which seem to be originally motivated by trying to make contact with the dead. If so, then it's very much a minority sect. Perhaps the authors might like to expand on the details further for those readers who are not familiar with religious practices, and how they are undertaken in Brazil. Would I recognise the same in Cape Town, to take a city at random. Would this be a typical Spiritist church: <https://goo.gl/maps/kwWe2B7didMk8vfDA>

We have included in the text some additional information of the religions studied in the article.

Some description of the geography of Recife would also help. Where are residential areas, where are industrial zones, is there a university, and so on.

We now include a figure with maps for socio-economic and demographic variables which help to provide additional context.

What's the reason for the choice of controls – what if we take another three, such as take-away food outlets, garden centres, and clothing/footwear shops? Would we get similar or different results? You could use simulation to build a distribution of randomly chosen groups of different land uses. I'm not proposing that this should happen, but it's a possibility.

The results for the various controls are qualitatively similar both for quadrat analysis and relative distribution. After choosing these three types of establishments semi-randomly and verifying their similarities, we think it unlikely that other types of common establishments would change the results. In this case simulation of a random variable is not useful, because it would detect clustering of all the events. Rather, what we are interested in is clustering of one type of event with respect to another.

I am reminded of Openshaw's early work on cluster detection – work was based around trying to link clusters of leukaemia to electricity substations, and overhead transmission lines. Alan Craft was rumoured to have asked something along the lines of "how do we know it's substations, or fish chip shops. What if it's telephone booths?" Openshaw turned his approach on its head to ask where the clusters were occurring. This lead him to a nuclear waste reprocessing plant, and an urban domestic waste incineration plant. Does the possibility of turning the question to look at this from another point of view?

This is a very perceptive comment. In fact, the approach that Openshaw pioneered was later converted into several forms of spatial scan statistics. Its legacy is still felt here: we can explore co-location patterns by considering signal events that we are interested in for theoretical/conceptual reasons (i.e., places of worship).

I'm left wondering whether this paper tells me something about spatial relationships in Recife. The author(s) assert that the research is exploratory. But to what extent might they apply elsewhere? Would these relationships translate to Vienna, for example?

The specific results are applicable to Recife only. However, the general principle could be more general, and it aligns well with one to two ideas: the Violence of the Just, or the possibility that violence is a consequence of religious intolerance. Irrespective of which of these two propositions is true, the general principle could be in operation in areas where conservative Evangelicals are present (similar results, although at the aggregated level, have been reported by Desmond et al., 2010). For this reason, Vienna might be a stretch, but other cities in Latin America and North America not so much.

I think that ASAP readers might be find this paper rarified. They certainly need help with some of the cultural issues.

We have made an effort to provide additional context, which we hope will make the paper more approachable to readers who are less familiar with the Latin American context.