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## Original article

### Indicators of violence and asthma: An ecological study

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#### ABSTRACT

**Background:** Global studies on asthma point to socioeconomic status as one of the main variables in terms of prevalence and disease severity in various parts of the world. Social factors related to community violence have been linked to higher incidence of asthma in the current studies. This study investigates the relationship between indicators of both community violence and development and hospital admissions due to asthma.

**Methods:** This was an analytical ecological study of multiple groups, using public databases with information up until 2006. All Brazilian municipalities with more than 100,000 inhabitants were considered as units of analysis. The main index used as socioeconomic indicator was the FIRJAN Index of Municipal Development (FIMD). The Index of Youth Vulnerability to Violence (IYVV) was used as indicators of community violence. The rate of admissions due to asthma was used as the outcome. Pearson's correlation was used for multivariate analyses. The coefficient of determination ( $R^2$ ) was calculated and the simple linear regression model adjusted for significant correlations.

**Results:** There was an inverse correlation between asthma admissions and FIMD ( $r = -0.354$ ,  $p < 0.001$ ), with statistical significance for all dimensions of the index. Admissions due to asthma were associated with the IYVV ( $r = 0.240$ ,  $p < 0.001$ ) and its component related to school attendance and employment ( $r = 0.315$ ,  $p < 0.001$ ), homicides ( $r = 0.112$ ,  $p = 0.034$ ), and poverty ( $r = 0.303$ ,  $p < 0.001$ ).

**Conclusions:** There was a direct correlation between indicators of violence and rates of admission due to asthma, and an inverse correlation with indicators of development. These results suggest that social detriment can act as a risk factor for hospital admissions due to asthma.

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## Introduction

Results published by different phases and places of the International Study of Asthma and Allergies in Childhood (ISAAC) were sufficient for researchers to conclude that the disease prevalence has increased worldwide. There is, however, insufficient information to explain the temporal trends and the values of variable distribution of its prevalence and severity around the world.<sup>1,2</sup> In view of the huge levels of social inequality that corrode the planet, one of the main factors that explains such variation is socioeconomic status.<sup>3–5</sup> Some studies have demonstrated that there is a higher

prevalence and severity of asthma, as well as worse disease control in poorer regions where living conditions are precarious.<sup>3–5</sup>

Multiple studies have attempted to explain the relationship between asthma and socioeconomic status.<sup>6–8</sup> Social factors, such as crime and drug-related neighborhood problems, as well as lack of family support have been associated with a higher incidence of asthma in young people.<sup>8</sup> Communities with a low socioeconomic status not only carry a higher burden of social issues, but they are also frequently characterized by high rates of crime and violence.<sup>9</sup> Violence is an inherently important source of stress both at individual and community levels.<sup>10–12</sup> The psychological stress of a child or their caregivers was considered an enhancer to the effects of well-established risk factors on asthma, such as traffic pollution and exposure to cigarette smoke.<sup>6,8</sup> By the viewpoint of psychoneuroimmunology stress-induced enhancement of IgE production, greater susceptibility to infection, conditioned histamine release and nerve/mast cell interaction and these factors can contribute to onset and exacerbation of asthma.<sup>13,14</sup> Community violence itself

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also demonstrated its direct role as an enhancer of classic risk factors of asthma.<sup>15</sup> Violence at its various levels, simply feeling unsafe or fearful<sup>11</sup> to witnessing<sup>11,12</sup> and being a victim of violence,<sup>10–12</sup> was presented as a significant factor associated to a higher prevalence of asthma.

A trend to associate higher prevalence and severity of asthma with indicators of community violence in different neighborhoods has been reported.<sup>9</sup> The ecological design is appropriate for such studies, since it analyses the effects that an entire population suffers with community violence, as opposed to the direct effect on an individual. Brazil is characterized by both significant social and income distribution inequalities, with clear disparities between regions,<sup>16</sup> where the violence–asthma relationship is particularly unexplored. Therefore, the aim of the present study was to analyze the associations observed between hospital admissions due to asthma and indicators of socioeconomic status and violence at an ecological level in different municipalities within Brazil.

## Methods

A search was performed using available indicators from databases of public domain. An epidemiological study of ecological design with analysis of multiple groups was performed. The rate of hospital admissions due to asthma was used as the study outcome and was calculated using data from the Department of Information Technology of the Unified Health System (DATASUS).<sup>17</sup> The independent variables were the Index of Youth Vulnerability to Violence (IYVV)<sup>18</sup> of the Brazilian Public Security Service in association with the Ministry of Justice and the FIRJAN index of Municipal Development (FIMD),<sup>19</sup> operated by the Federation of Industries of the State of Rio de Janeiro (FIRJAN), with data from all Brazilian municipalities. The information available for the year 2006 was used to allow a synchronic analysis, since this was the last time period for which all the information was uniformly available.

The IYVV<sup>18</sup> was created to integrate relevant variables in the association between young people and violence in an index, depicting the situation found in the covered municipalities. Therefore, the index can be decomposed into five dimensions: two reflecting injury from external causes - incidence of homicides and traffic accidents - one that reflects educational conditions and involvement in crime - proportion of individuals who lack school or work - and two reflecting socioeconomic characteristics - variables expressing poverty levels (low-income) and inequality.

Based on the FIMD, FIRJAN objectively reclassifies all Brazilian municipalities annually, using exclusively official data. In addition to the overall score, the index can be split into three dimensions: employment and income; education; and health. These were used as an indicator of socioeconomic status.<sup>19</sup>

Brazilian municipalities with more than 100,000 inhabitants were considered as units of analysis, owing to their being considered large, as per the National Policy for Social Services,<sup>20</sup> which amounted to a total of 266 towns.

Brazil is composed of 5 official regions, which were established in order to aid statistical interpretations and implementation of administration systems of public interest. These federal states are grouped in the following regions: North, Northeast, Central-West, Southeast and South. The descriptive analysis of the present study used such regions to expose grouped municipal data and to subjectively assess the behavior of the different indicators in each region.

The variables were tested using Kolmogorov–Smirnov, which revealed that the null hypothesis of normal distribution could not be rejected. Bivariate analyses were therefore plotted in dispersion diagrams and evaluated using Pearson's correlation coefficient at a significance level of  $p < 0.05$ . The independent variables, both in their overall presentation and in their split dimensions, were

correlated with the rate of hospital admissions due to asthma. Whenever the correlations were significant, the coefficient of determination was measured ( $R^2$ ).

The Ethics Committee in Research of the University of Southern Santa Catarina (number 11.476.4.01.III) approved this study.

## Results

In 2006, Brazil reported a total of 272,712 hospital admissions due to asthma (14.4 per 10,000 inhabitants), of which 82,986 comprised our target population, which included towns with more than 100,000 inhabitants. The regional distribution of admissions due to asthma from towns with over 100,000 inhabitants and the data analysis in terms of regional rates are described in Table 1.

The average scores of the FIMD and its dimensions by municipalities with over 100,000 inhabitants are presented in Figure 1. Towns in the North and Northeast had the lowest scores for this socioeconomic index, both overall and in terms of individual dimensions.

The relationship between municipal rates of admissions due to asthma and the socioeconomic index (FIMD) is described in Table 2. A significant yet inverse correlation was observed ( $r = -0.354$ ,  $p < 0.001$ ). The dimensions with the highest scores were health ( $r = -0.350$ ,  $p < 0.001$ ) and education ( $r = -0.347$ ,  $p < 0.001$ ), both with determination of up to 12%.

Regarding the community violence index (IYVV) and its dimensions, their average scores are described in Figure 2. The North and Northeast regions showed the highest scores, especially in terms of poverty, as well as school and job absence. The highest homicide rates were found in towns from the Northeast and Central-West regions. The South and Central-West had the highest rates of road traffic accidents. Finally, the inequality dimension demonstrated similar levels in all Brazilian regions, except for the Central-West.

The relationship between the rates of admissions due to asthma and community violence (IYVV) is described in Table 3. A positive and significant correlation was found between violence and admissions for asthma ( $r = 0.240$ ,  $p < 0.001$ ). The IYVV was responsible for up to 5.8% of the variation in admissions ( $r^2 = 0.058$ ), however, only the components relating to school and job absence ( $r = 0.315$ ,  $p < 0.001$ ), homicides ( $r = 0.112$ ,  $p = 0.034$ ) and poverty ( $r = 0.303$ ,  $p < 0.001$ ) were associated, particularly the first variable in terms of magnitude. Figure 3, 4 show the relationship between municipal rates of admissions due to asthma and the socioeconomic index and between violence and admissions for asthma, respectively.

## Discussion

The present study used public databases to gather information about all Brazilian towns with more than 100,000 inhabitants in

**Table 1**  
Regional distribution of admissions due to asthma from towns with over 100,000 inhabitants in 2006.

Region	Number of towns	Sum of admissions	Sum of population	Regional rate of admissions (per ten thousand)
North	19	5834	6,676,153	8.7
Northeast	53	26,949	20,168,586	13.3
Central-west	15	6562	7,117,752	9.21
Southeast	135	35,210	54,615,834	6.4
South	44	8468	12,499,304	6.7
Total	266	82,986	101,077,629	

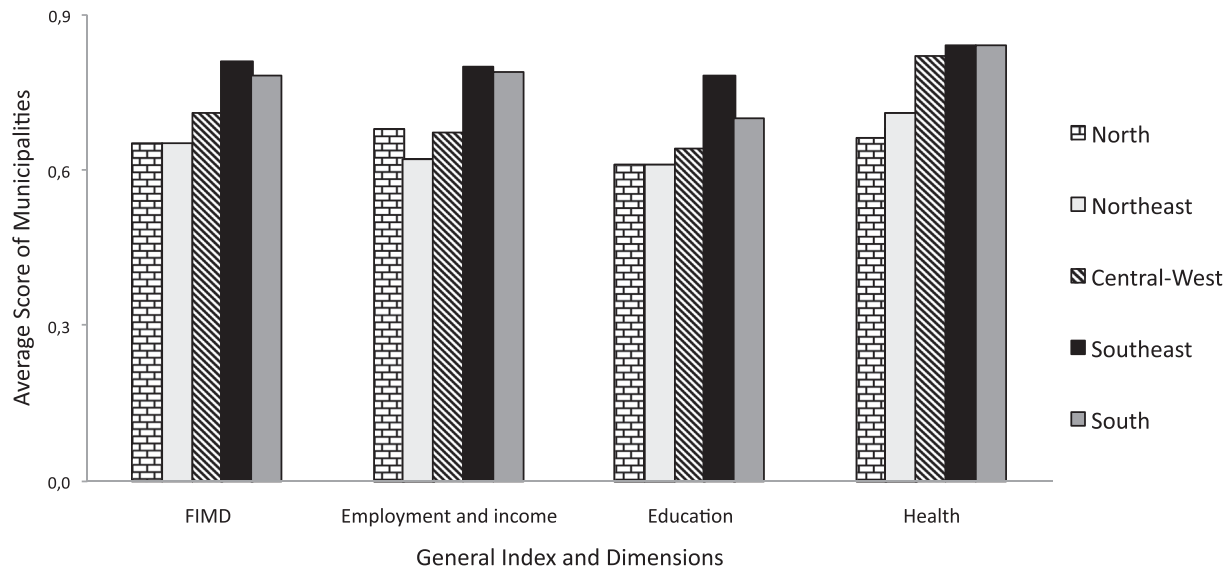


Fig. 1. Average scores of the FIMD and its dimensions by municipalities with over 100,000 inhabitants.

**Table 2**  
Relationship between municipal rates of admissions due to asthma and the FIMD with its dimensions.

Index or dimension	r	p-value	R <sup>2</sup> (%)
General index			
FIMD	-0.354	<0.001	0.125 (12.5%)
Dimensions			
Employment and income	-0.251	<0.001	0.063 (06.3%)
Education	-0.347	<0.001	0.120 (12.0%)
Health	-0.350	<0.001	0.123 (12.3%)

FIMD, FIRJAN index of Municipal Development; r, Pearson's Correlation; R<sup>2</sup>, Coefficient of Determination.

**Table 3**  
Relationship between municipal rates of admissions due to asthma and the IYVV with its dimensions.

Index or dimension	r	p-value	R <sup>2</sup> (%)
General index			
IYVV	0.240	<0.001	0.058 (05.8%)
Dimensions			
School and job absence	0.315	<0.001	0.099 (09.9%)
Poverty	0.303	<0.001	0.092 (09.2%)
Inequality	0.049	0.211	–
Homicides	0.112	0.034	0.013 (01.3%)
Road traffic accidents	0.016	0.394	–

IYVV, Index of Youth Vulnerability to Violence; r, Pearson's Correlation; R<sup>2</sup>, Coefficient of Determination.

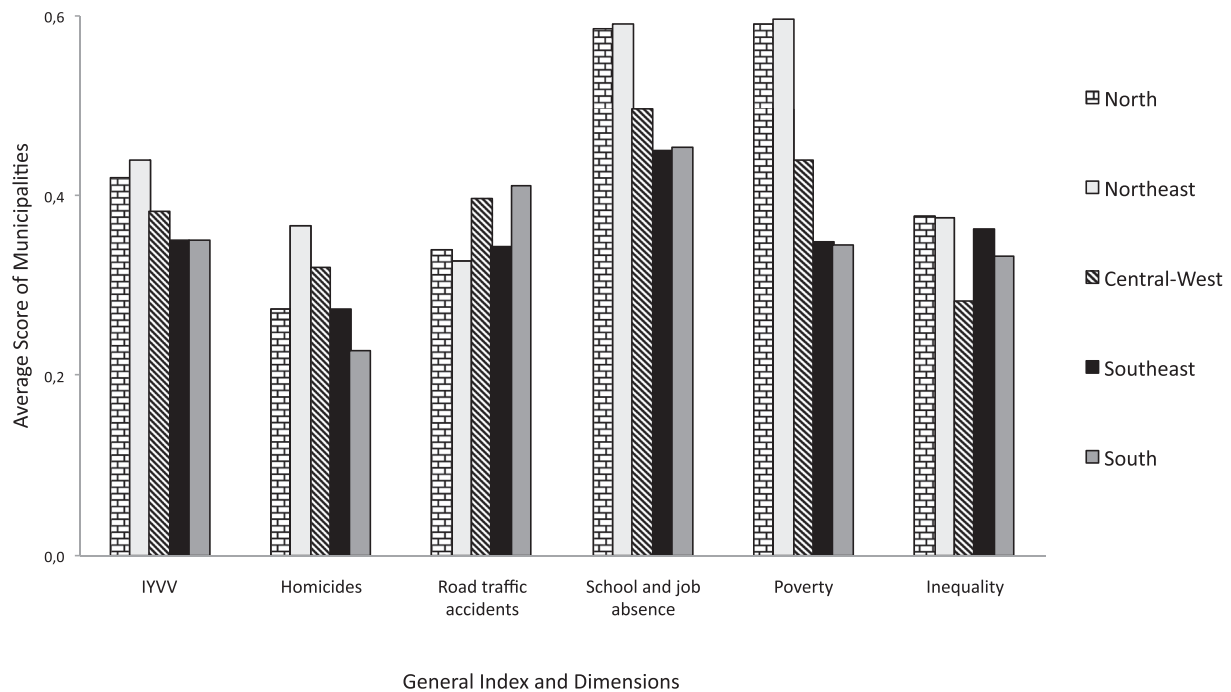


Fig. 2. Average scores of the IYVV and its dimensions by municipalities with over 100,000 inhabitants.

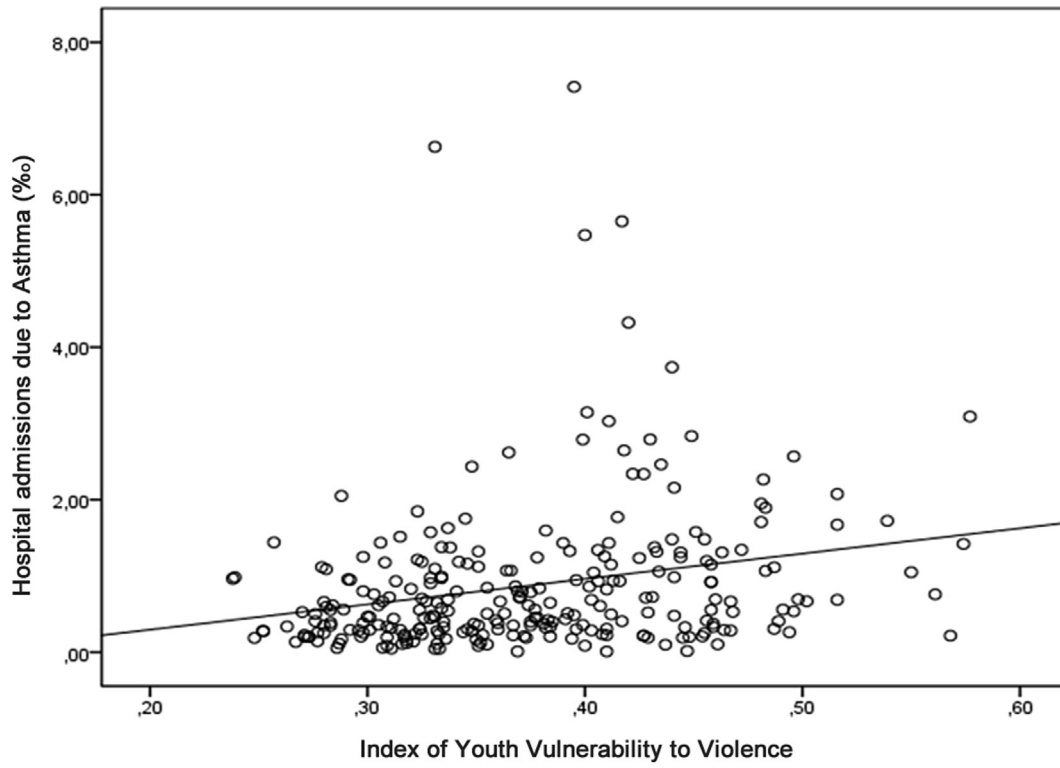


Fig. 3. Relationship between admissions due to asthma and the violence index.

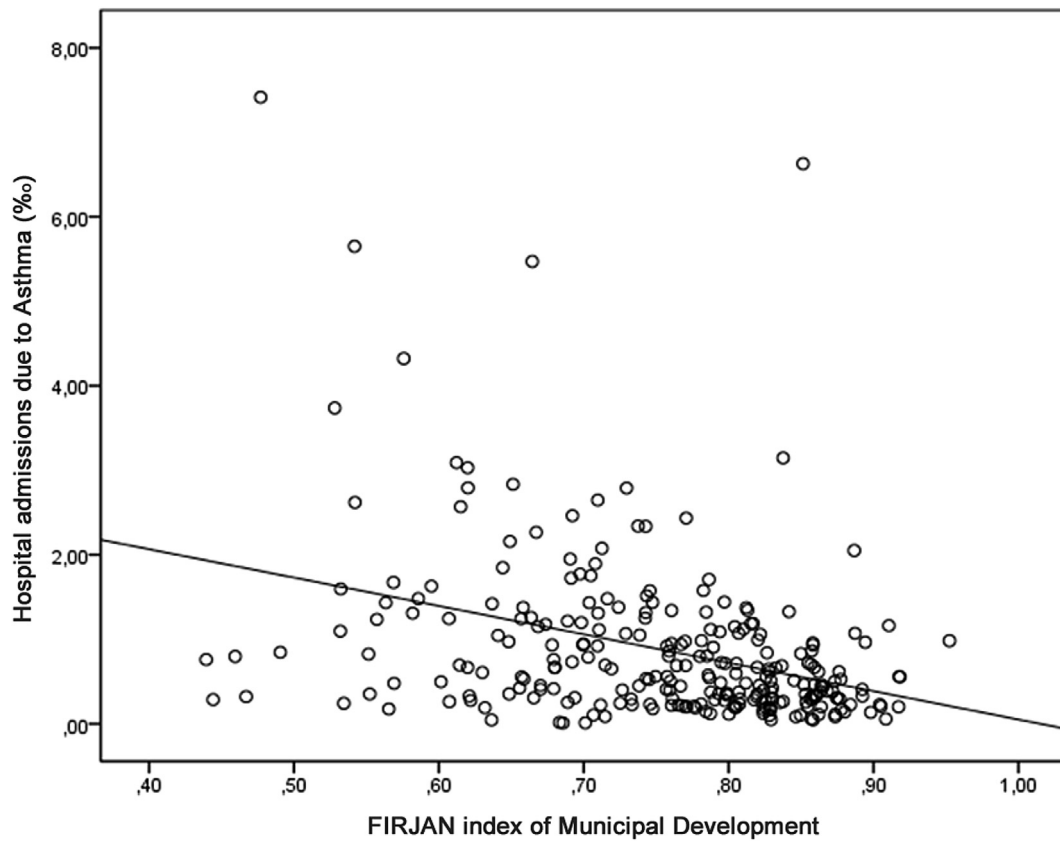


Fig. 4. Relationship between admissions due to asthma and the socioeconomic index.

2006, totaling 266 municipalities. The relationships that could be observed at the ecological level between socioeconomic and violence indicators, and hospital admissions due to asthma were investigated. Two novel indicators were used, created to generate research in public health and offered a reliable methodology. The FIMD was used as the socioeconomic marker, whilst the IYVV as a marker of community-related violence.

The rates of hospital admissions due to asthma reflect morbid exacerbation of this illness, acting as reliable markers for the level of disease control. According to the latest GINA consensus, any exacerbation is indicative of the need to review the maintenance treatment.<sup>21</sup> Data from the World Health Survey published in 2012 placed Brazil amongst the five countries with the highest prevalence of asthma (13.0%), behind Australia (21.5%), Sweden (20.2%), the United Kingdom (18.2%) and Holland (15.3%).<sup>22</sup> Corroborating the prevalence, the 272,712 hospital admissions in 2006 presented in this study suggested asthma as the 4th cause of hospital admissions in Brazil in that year and demonstrated that the country had a considerable lack of control over the disease.<sup>17</sup> In June 2012 the Brazilian government initiated free distribution of three specific medications for asthma control (Ipratropium Bromide, Beclomethasone and Salbutamol) aiming at reducing hospital admissions and deaths due to asthma.<sup>23</sup> Such intervention may in future reflect positively on the morbidity and mortality rates for asthma in Brazil.

The contrast of reality and socioeconomic development across the Brazilian regions are relevant and possible determining factors of variation of prevalence and disease severity.<sup>3–5</sup> This study objectively measured these overall characteristics via the FIMD. When comparing the average FIMD scores obtained from each region, it is evident that they are lower where hospital admission rates for asthma are higher. The direct analysis between the overall municipal hospital admission rates for asthma and FIMD resulted in an inverse correlation with an  $R^2$  of 0.125. It is therefore possible that up to 12.5% of the increase in admissions due to asthma may be as a result of a decrease in socioeconomic development. The results have demonstrated that more developed towns tend to have a higher control of asthma, which is consistent with previous studies that report a significant association between low socioeconomic status and poor morbidity, including an increase in disease prevalence and severity, as well as a greater number of visits to emergency services and hospitalizations.<sup>3–5</sup>

The negative correlation between admissions due to asthma and the FIMD dimension of employment and income corroborates previously published data,<sup>4,24</sup> as demonstrated in the United States by Gwynn,<sup>24</sup> with adult individuals from 50 federal states, where it was observed that the lower the family income the higher the prevalence of recently diagnosed asthma. A reduced income may also prevent access to the medication necessary to control the disease, which may often be refractory and require higher doses or different drug components. In 2006 only 7 drugs were available (in 32 forms) on the government program of discounts.<sup>23</sup>

The level of education of asthmatic individuals and their ability to understand the instructions given are crucial to the adequate control of the disease.<sup>25–27</sup> Watson *et al.* divided 398 children who frequently visited emergency rooms for asthma attacks into two groups, one with the usual instructions received from the doctors and another with the educational intervention of an interactive program without modifying their medication. Using educational material alone, the authors were able to reduce emergency visits by 38%.<sup>27</sup> The results from the present study have shown an inverse correlation between admissions due to asthma and the education dimension of the FIMD, corroborating the aforementioned study. Bacon *et al.*<sup>3</sup> investigated the relationship between asthma and

socioeconomic factors in 781 asthmatic adults and concluded that a higher prevalence of unhealthy behaviors among asthmatic adults with a low level of education may in part explain such a strong relationship. Many authors corroborate this finding.<sup>3–5,7,9,26,27</sup>

Further insight into the socioeconomic universe showed that recent studies suggest a coherent relationship between community violence and asthma prevalence and severity.<sup>7,12,15,28–32</sup> Community violence is herein defined as a sensation of being unsafe as a result of several negative factors that disturb the harmony and social living, such as crime, exposure to illegal drugs, poverty, unemployment and inequality. The dimensions that compose the IYVV measure these exact factors and are more suitable to detect levels of community violence than trauma or individual victimization.

The descriptive analysis of the data in this study revealed that the Brazilian regions with the highest average IYVV scores were the North, Northeast and Central-West for almost all dimensions. The same regions presented the highest rates of hospital admissions due to asthma. The dimensions of road traffic accidents and inequality were the only variables in which the South and Southeast regions were at the same level as the others. They were, however, also the only two dimensions that did not correlate with asthma. Bivariate analysis revealed a direct relationship between IYVV and municipal hospital admissions due to asthma. These data indicate that the towns most exposed to community violence have a lower control of asthma and, consequently higher hospital admissions. An  $R^2$  of 0.058 indicates that up to 5.8% of the increase in hospitalizations may be due to a concomitant increase in the IYVV, which is in agreement with other studies.<sup>7,12,16,28–32</sup> Swahn and Bossarte studied 15,214 high-school students in the USA and demonstrated, via interviews, that those who felt unsafe even within the school or *en route* to or from school had a significantly higher prevalence and poorly controlled asthma.<sup>10</sup>

The main hypotheses that could explain the relationship between community violence and asthma agree that this type of disharmonic sensation caused by surrounding violence is a source of psychological stress<sup>33,34</sup> and, as such has a direct impact on the immune system<sup>13</sup> and lung function.<sup>33</sup> This could vary from an imbalance between oxidant and antioxidant agents, to the activation of the hypothalamic-pituitary-adrenal axis with cortisol release.<sup>8,12,33,34</sup> In fact, Suglia *et al.* observed in a prospective study with 43 children that higher symptoms of stress related to community violence predicted higher levels of salivary cortisol.<sup>35</sup>

Regarding the school and job absence dimension of the IYVV, the direct correlation with asthma found in this study was within the expected, as per previously discussed under the education dimension of the FIMD. The basic difference is that for the IYVV, the value is generated from the number of truant children and unemployed adults, as opposed to municipal investments in education. The lack of schools is intimately related to a higher rate of illegal drug use, which is one of the components of community stressors already described as being related to uncontrolled asthma.<sup>7</sup> The unemployment generate a psychological stress; if it is also associated to higher rates of depression, it leads to a negative impact on disease control.<sup>11,29,33</sup>

A direct correlation was detected in this study between the poverty dimension and hospital admissions due to asthma. It is interesting to note, however, that poverty may act both directly as a socioeconomic factor *per se* and indirectly as one of the stressor components of community violence, as measured by the IYVV.

A study by Jeffrey *et al.* in different census sectors of the city of Los Angeles in the USA reported a positive correlation (0.540) between hospitalizations for asthma and hospitalizations for mugging.<sup>9</sup> Likewise, the present study identified a positive correlation of

0.112 for the homicides dimension of the IYVV. The larger magnitude encountered in the American study may be explained by the fact that street robbery (mugging) is the most comprehensive category of crime, including homicides as an outcome, which generates greater media attention and greater impact on the sensation of safety by the population.

The effects of violence are felt by the entire community and not just by their victims. The ecological design has been advocated as appropriate for studying such relationship,<sup>9</sup> however, limitations that must be highlighted. The ecological design, in order to prevent fallacy, prohibits any interference over the effect that community violence or low socioeconomic status may have at the individual level. Furthermore, the information transmitted to the public databases used herein is fed by an open system, which makes it impossible to quality assure the gathered data. Therefore, this type of study permits the formulation of hypotheses that can be confirmed or rejected by future cross sectional and longitudinal studies.

Additionally, the search for asthma related factors dispersed through the sociocultural environment is important in order to break with the strictly biomedical approach to the asthmatic patient. Control and adherence to disease treatment are more difficult to achieve when there is an impeding psychosocial load and, consequently, the rates of exacerbation and hospitalization are increased.

It is likely that the first steps, which envisage to reach an appropriate environmental control and educate the patient regarding their disease, may be more difficult to achieve in an individual with a low level of education, living in an unfavorable socioeconomic and possibly violent reality. Studies are necessary to evaluate the impact of public health measures that facilitate access to some medications on hospital admissions due to asthma.

It is clearly evident that the educational approach should be tailored to the individual, however, it is possible that such customization could reach a community level, i.e., specific to the community in which the subject lives. Therefore, in addition to professional health guidance, it may be necessary to intervene with educational programs or support groups directed at communities with a higher incidence of hospital admissions, taking into account their social peculiarities.

In conclusion, this study suggests that social detriment can act as a risk factor for hospital admissions due to asthma. In view of the data presented herein, it is reasonable to highlight socioeconomic factors as contributors to such global variation in the prevalence of asthma. The role of community violence in this context, though uncertain, has sufficient evidence to be considered as an obstacle in asthma control and must be taken into account when planning treatment.

#### Conflicts of interest

The authors have no conflict of interest to declare.

#### Authors' contributions

All people listed as authors of this article meet the authorship criteria. They contributed substantially to study planning, data collection or interpretation of results and wrote or critically revised the MS and approved its final submitted version. FOT contributed to the conception and designed of the study, collected data and wrote most parts of the manuscript. RBD and ASM contributed to interpretation of the results and critical revision of the manuscript. JLT performed the statistical analysis and interpretation of the results. JS contributed to the conception, design and revision of the study and had the primary responsibility for the final content. All authors have read and approved the manuscript as submitted.

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