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The profile of the population affected by natural disasters in Brazil

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Abstract

Disasters are calamitous events that disrupt community activities. The profile of the population affected by disasters differs according to the disaster type and the site vulnerability. In this study, the natural disaster victims profile in Brazil is addressed. Statistical analyses are used to guide preventive activities for the population under risk.

Keywords: Affected population profile, Humanitarian Logistics, Natural Disasters, Statistics

1. Introduction

According to IFRC (2008), disaster means a serious disruption of a society's functioning which poses a significant widespread threat to human life, health, property or the environment, whether arising from accident, nature, or human activity suddenly or slowly. Natural disasters (e.g. floods, droughts, earthquakes, hurricanes, famine) or man-made disasters (e.g. wars, conflicts, and refugee crisis) have increasingly impacted communities and nations around the world in recent decades, and forecasts suggest that the trend will continue (EM-DAT, 2011).

Each year, millions of people are affected by man-made and natural disasters that can trigger humanitarian crises. Humanitarian organizations, such as NGOs (non-governmental organizations), United Nation (UN) agencies or governments, work to help and support the affected communities, by delivering water, drugs, medical equipment, shelter, and food items, among others (ROTTKEMPER *et al.*, 2011).

O'Keefe *et al.* (1976) introduced the concept of vulnerability and concluded that vulnerability presented a rising trend. These authors claimed that socioeconomic conditions as the main causes for natural disasters. Rodriguez *et al.* (2007) stated that risks and disasters are socially constructed phenomena, influenced by political and social structure, availability of resources, stratification and inequality between inhabitants, population growth, density, and distribution and environmental degradation.

In a special session of the 2000 UN General Assembly, named 'Gender equality, development and peace for the twenty-first century', the adaptation of disaster reduction policies for different affected population profiles was identified as a necessity. This session highlighted the inefficiencies and inadequacies of existing approaches and intervention

methods to respond to natural disasters (SILVERSTEIN, 2008). A report of the World Health Organization (WHO, 2002) pointed out the gendered nature of disaster vulnerability and the lack of research on this subject.

Episodes such as the earthquake and tsunami in Asia (2004), the earthquakes in Pakistan (2005), China (2008), Chile (2010), Haiti (2010), and in New Zealand (2011); the floods and landslides in Brazil (2008, 2009, and 2011), the series of disasters in Tohoku, Japan (2011), among others, have demonstrated the vulnerability of the societies even in developed nations.

Global warming has also aggravated the severity and frequency of global disasters and has been embedded in political and public debates (KUN *et al*, 2010). Forecasts estimate that over the next 50 years natural and man-made disasters will increase five times in number and severity (THOMAS and KOPCZAK, 2005). In Brazil, more frequent storms are predicted in the Southeast region due to global warming (FAPESP, 2011) which has encouraged the investment in disaster prevention and preparedness.

This paper aims to analyze the profile of the populations affected by natural disasters in the Brazilian state of Sao Paulo in the period 2005 to 2011, considering age, gender, and geographical characteristics of victims according to the most recurrent types of accidents in Sao Paulo: landslides, floods, lightning, and collapses. The research was based on real data provided by the Civil Defense of the State of São Paulo which is in charge of accounting the fatal victims of disasters. The State of Sao Paulo concentrates about one fifth of the Brazilian population. In this state, more than 39 million inhabitants are distributed in municipalities of different demographic profiles: 88% of them have less than 100,000 inhabitants and correspond to 25% of the state's population, whereas 16% of the municipalities belong to metropolitan regions which total 68% of the state's population (IBGE, 2011). Furthermore,

the inhabitants of this state are settled in various types of terrains, including coastal areas, plateaus and low mountain regions. In the State of Sao Paulo, as in the whole of Brazil, the population is annually affected by floods, landslides and lightnings which generate fatal victims during the wet months.

The remainder of this text is organized as follows. A brief literature review is presented in section 2 and focused on the description of gender studies in disasters. Section 3 describes the natural disasters in Brazil through geographical characteristics of Brazil and the State of Sao Paulo. Results and discussion are presented at section 4 through classification of the affected population, sources and criteria of statistical analysis, and multivariate logit regression of the natural disasters. The concluding remarks are in section 5.

2. The evolution of gender studies in humanitarian logistics

O'Keefe *et al.* (1976), in Nature Journal, was the first publication to detect the interface between natural disasters and the vulnerable human population segments. At that time, they explained that the increase of natural disasters victims was caused by population growth. 'As population continues to expand, and the resources continue to be controlled by a minority, the real standard of living drops for much of world's population'. The more a population grows, the more vulnerable it becomes. To reduce this vulnerability, preventive planning should be established, considering the geographical and geological aspects, socio-economic and cultural status.

According to Neumayer and Plümper (2007) and O'Keefe et al (1976), gender, biological, and physiological differences in capacity for disaster response can lead to different mortality rates because, among others reasons, that men can be physiologically better equipped to

survive a disaster physical impact. For instance, if a woman is less strong than male, she will be more easily swept away by water, snow or land. On the other hand, under disaster scenarios, women are usually slower in crucial physical activities, such as running, climbing trees, and reaching rescue points.

Chou *et al* (2004) studied the risk of death in earthquakes. The literature suggests that mental and physical health limitations can affect disaster response. Also, that health and socioeconomic status (SES) could be two important determinants of earthquake vulnerability, but little is known about the relation between these risks factors and earthquake-related death.

Other important aspects of disasters are the efforts in communication, mobilization and training of people under risk used as a way of disaster prevention. Thus, to be effective, the efforts must consider the specificities of population groups, according to gender, age and socioeconomic (SES) conditions. West and Orr (2007) claim that despite the magnitude of a disaster and emergency planning, not enough is known about how people perceive their vulnerability and what affects their motivation to evacuate in cases of disaster. It is not obvious what influences perceptions of vulnerability, how citizens judge various governmental and nongovernmental information sources, nor the role played by gender in decision making under disasters.

West and Orr (2007) observe that women and minorities are more likely to evacuate if recommended by the government or media. Some of the greatest losses of lives have taken place when people disregarded official recommendations to evacuate. During the Katrina (New Orleans), those who ignored or did not receive government warnings, or were unable to leave because of lack of transportation, were much more likely to die when the floodwaters arrived.

Neumayer and Plümper (2007) explain the difference in impact of natural disasters in life expectancy on female as compared to male not only for different physical exposures and physiological or biological gender differences, but also for the different vulnerabilities socially constructed that originate from social roles that men and women assume, voluntarily or involuntarily, as well as patterns of gender discrimination. They claim that unequal exposures to risks are a consequence of the socio-economic system and provide the first systematic, quantitative analysis of gender differences in natural disaster mortality. They find that natural disasters, on average, the more so the stronger the disaster, kill more women than men or kill women at a younger age than men.

Doocy *et al.* (2011) analyzed if geographic location was a key determinant of access to health services and humanitarian assistance of Iraqi refugee in Jordan and Syria. They observed that both the population concentration in densely populated urban areas and distant and remote places are factors that cause difficulties in humanitarian assistance to meet the specific demands and contexts of this population.

Geographic Information Systems (GIS) are used for studies in humanitarian operations in order to map the events and verify geographic factors that may influence such events. The work by Barbosa *et al.* (2009) illustrates the use of GIS for the annual survey of historical events in the Paraíba River Valley (State of São Paulo – Brazil) in the period 1997 to 2009 for installation location of a relief supply depot.

For statistical verification of data, logistic regression was used, similar to that used in epidemiological studies multivariate. In the logistic model, the values of a series of independent variables are used to predict the occurrence of the disease (dependent variable). Thus, all variables considered in the model are controlled together. As a series of independent variables are used, it is a multivariable problem. The factors may be crossed. The measure of

association calculated from the logistic model is the odds ratio. The adjusted odds ratios are obtained by comparing individuals who differ only in the characteristic of interest and have the values of other variables constant (DOBSON AND BARNETT, 2008).

3. Problem description of natural disasters in Brazil

3.1. Geographical and population study

Brazil has an area of de 8,514,876.599 km^2 and a population of 190,732,694 inhabitants (IBGE, 2012). It is a country with continental dimensions (Europe - 10,530,751 km^2). The most common natural disasters in Brazil are drought in the Northeast and floods and landslides in the South and in the Southeast, as well as isolated events such as hurricanes caused by the South Atlantic Convergence Zone (ZCAS). The country´s climate is influenced by the events La Niña and El Niño (INPE, 2012). The State of São Paulo is located in the Southeast Region of Brazil, has an area of 248,209,426 km^2, similar to some countries as for example the United Kingdom - and a population of 42,262,199 inhabitants (similar to that of Canada). On the map below (figure 1) Brazil and the State of Sao Paulo, are displayed.

Figure 1: Brazil and the State of Sao Paulo Map

The State of Sao Paulo has a predominantly tropical climate with well defined rainy (December to March) and dry (June to August) periods. The topography consists of a coastal plain, an eastern region consisting of valleys and mountains (SÃO PAULO, 2012). These characteristics cause the risk of landslides in these areas. Figure 2 shows the map of State of Sao Paulo relief and the mountains in the east region.

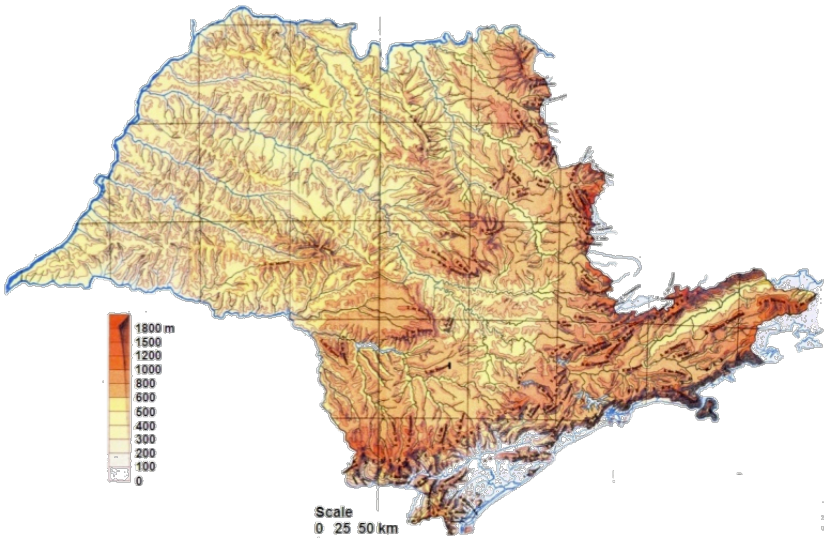

Figure 2: State of Sao Paulo relief map (Libault, 1971)

According to the Brazilian laws (CIVIL DEFENSE, 2007) every city must have a team responsible for the activities for the joint and coordination of activities the activities of prevention and reduction of natural disasters effects. In each state of the federation there is a coordination team for this system at the state level. During the rainy season, a process called "*Operação Verão*" (Summer Operation) is performed by state civil defense team. The real data of victims presented in this paper are from these operations by the Civil Defense of the State of Sao Paulo in the years 2005 to 2011.

The natural disasters that occur more frequently in the State of São Paulo, due to the rainy season and to the topography are classified according to EM-DAT (2012) in: landslides (hydrological), floods (hydrological) and lightning (meteorological, local/convective storm). Another type of accident, collapse ("Accident involving the collapse of a building or structure, which can either involve industrial structures or domestic / non-industrial structures") (EM-DAT, 2012), despite not considered by the EM-DAT disaster was considered herein due to specific characteristics and differences in relation to landslides, that occur during the rainy season.

In Brazil every 10 years the Population Census is held, consisting of a meticulous survey of all the households in the country. Based on data from this census, the State of São Paulo has a population of 41,262,199 inhabitants (IBGE, 2010). 75% of the population is concentrated in the eastern region of the state, where the capital and three metropolitan areas are located.

3.2. Age classification

The purpose of age classification is to facilitate the synthesis of collected data and the investigation on how disasters affect different groups of people. Once this task is accomplished, disaster reduction efforts may be better oriented according to population segments, which is of particular interest for humanitarian and civil defense organizations.

The following age classification has been adopted in this study: children (0 to 14 years old), youth (15 to 24 years old), adults (25 to 60 years old) and elderly (over 60 years old).. This classification was considered according to the United Nations recommendation in "Tables in household characteristics". The *elderly* does not totally agree with the United Nation's recommendation because it has not been subdivided into 5year old groups (United Nations,

2004). The chosen classification is reasonable both in terms of data analysis (graphics X, Y and Z) and cultural background, considering the social roles played by Brazilian citizens of different ages.

4. Results and discussion

Two types of analysis have been preformed, a preliminary, in which we compared the percentage of victims versus the population percentage (Chou *et al*, 2004), in order to detect the places where the events occur, thus allowing to estimate the population at risk and also some pronounced incidence of age and gender in the local population. This analysis is important to define the variables of reference for the multivariate analysis. The second type of analysis refers to multivariate analysis using Logistic Regression in order to determine which factors influence the occurrence of natural disaster victims. In the results, Odds ratio (OR) and Estimate Coefficient were considered with the following variables:

- Gender: Female or Male;
- Age: Children, Youth, Adult, Elderly;
- Month: December, January, February, March/April (March was grouped with April due to the amount of data);
- Climate Influence: El Niño, La Ninã, None.

All variables were codified in a binary way. The variables of reference were assigned values equal to 0. The software R, version 2.11.1, (2010 The R Foundation for Statistical Computing), was used for the logit regression analysis (function glm, family=binomial).

4.1. Landslides

Tables 1 and 2 show the amount of landslides events per age group and in relation to the population proportion of the regions where this type occurs. Most of the victims are observed to be concentrated in the group of women below 14 years old. This type of result was also noticed by Neumayer and Plumper (2007) and can be explained in terms of physical (strength and agility) and socio-economic reasons, because there is a tendency for women and girls to remain a greater amount of time within their residences, at higher risk of becoming victims of landslides.

Table 1*: Fatal victims of landslides: preliminary analysis of age and gender*

Age (years)	**Male**					**Female**				
	Cases		Population		Ratio	Cases		Population		Ratio
	No.	%	No.	%		No.	%	No.	%	
0 - 14	14	14.3%	3,457,016	10.9%	1.3	29	29.6%	3,345,045	10.6%	2.8
15 - 24	5	5.1%	2,632,856	8.5%	0.6	5	5.1%	2,611,146	8.3%	0.6
25 - 59	18	18.4%	7,515,729	24.2%	0.8	17	17.3%	8,140,293	25.9%	0.7
> 60	7	7.1%	1,464,474	5.0%	1.4	3	3.1%	1,970,005	6.6%	0.5
Total	44	44.9%	15,070,075	48.7%	0.9	54	55.1%	16,066,489	51.3%	1.1

n = 98 cases, p = 31,136,564 total habitants (in the state's east region). Ratio = cases$_{\%}$/population$_{\%}$

Table 2: *Fatal victims of landslides: preliminary analysis of citiy sizes*

City size (resident habitants)	**Cases**		**Population**		**Ratio**
	No.	%	No.	%	
<100,000 (570 cities)	28	28.6%	10,438,191	25.3%	1.1
100,001-500,000 (66 cities)	39	39.8%	14,172,516	34.3%	1.2
500,001-10,000,000 (8 cities)	19	19.4%	5,992,106	14.5%	1.3
>10,000,000 (Sao Paulo only)	12	12.2%	10,659,386	25.8%	0.5
Total	98	100.0%	41,262,199	100.0%	

n = 98 cases, p = 41,262,199 habitants. Ratio = cases$_{\%}$/population$_{\%}$

Figure 3 shows the location of the victims. It is observed that the victims are concentrated in the eastern region.

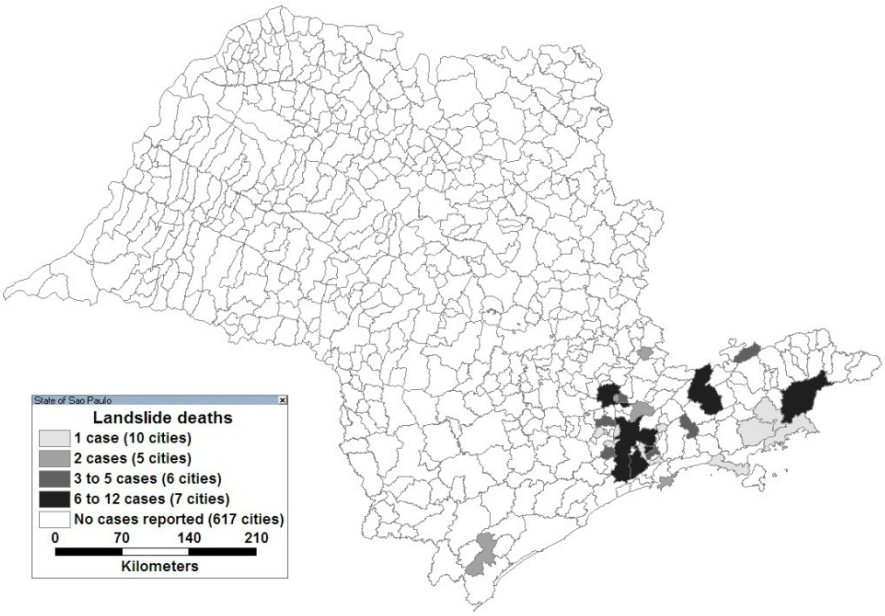

Figure 3: . Location of fatal victims of landslides.

The results of multivariate logit regression confirm influence of gender (OR = 2.18) and a significant influence of age Children (OR = 8.13). The variable month, which was not considered in the preliminary analysis, but was included in the multivariate analysis showed a strong influence in the occurrences of landslides in the month of January (OR = 2.18).

For the landslides events, the variables of reference were: Male (Gender); Elderly (Age); December (Month) ; None (Climate Influence).

4.2. Floods

In this type of accident it is observed in Tables 3 and 4 that the largest number of victims are male (70.7% of the victims X 48.7% of the population), mainly adults. This can be explained in terms of cultural and socio-economic factors, the characteristics of the male labor and the fact that man, as compared to women, underestimate risks more, for example, when trying to save their possessions during a flood.

Table 3*: Fatal victims of floods – preliminary analysis of gender and age*

Age (years)	**Male**					**Female**				
	Cases		Population		Ratio	Cases		Population		Ratio
	No.	%	No.	%		No.	%	No.	%	
0 - 14	12	16.0%	4,506,645	10.9%	1.46	3	3.8%	4,354,273	10.6%	0.4
15 - 24	3	4.0%	3,502,704	8.5%	0.47	4	5.1%	3,438,892	8.3%	0.6
25 - 59	29	38.7%	10,004,998	24.2%	1.59	13	16.7%	10,683,251	25.9%	0.6
> 60	9	12.0%	2,063,526	5.0%	2.40	5	6.4%	2,707,910	6.6%	1.0
Total	53	70.7%	20,077,873	48.7%	1.45	25	32.1%	21,184,326	51.3%	0.6

n = 78 cases, p = 41,262,199 total habitants. Ratio = $\text{cases}_{\%}/\text{population}_{\%}$

Table 4*: Fatal victims of floods – preliminary analysis of cities' sizes.*

City size (resident habitants)	**Cases**		**Population**		**Ratio**
	No.	%	No.	%	
<100,000 (570 cities)	26	33.3%	10,438,191	25.3%	1.3
100,001-500,000 (66 cities)	22	28.2%	14,172,516	34.3%	0.8
500,001-10,000,000 (8 cities)	9	11.5%	5,992,106	14.5%	0.8
>10,000,000 (Sao Paulo only)	21	26.9%	10,659,386	25.8%	1.0
Total	78	100.0%	41,262,199	100.0%	

n = 78 cases, p = 41,262,199 total habitants. Ratio = $\text{cases}_{\%}/\text{population}_{\%}$

Figure 4 illustrates the location of the victims. It is observed that the victims are in all the state.

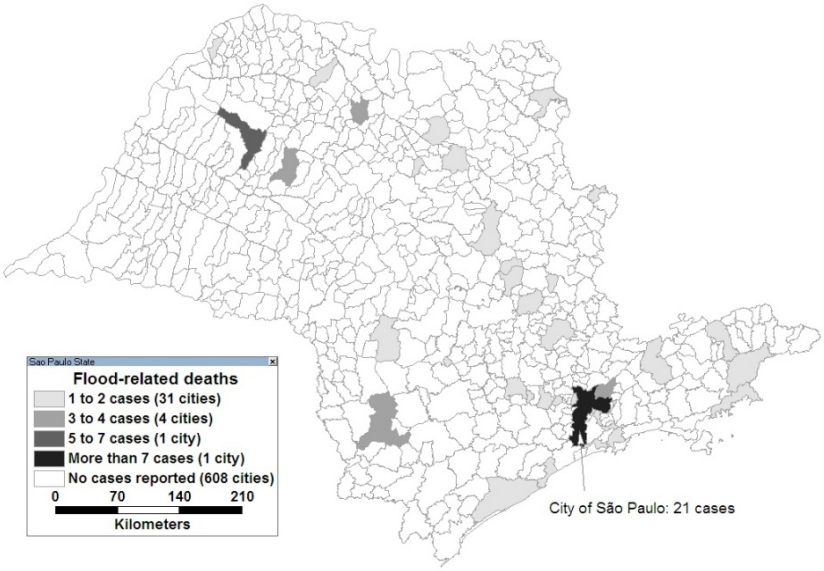

Figure 4:. Location of fatal victims of flood-related causes

The results of preliminary analysis and multivariate logit regression showed that men have a slight higher probability to be victms of floods (OR = 1.51) than women. Children (male + female) have a strongly less probability to be victims of floods (OR = 0.28 and EC = -1.2).

For the floods events, the variables of references were: Female (Gender); Elderly (Age); March/April (Month); None (Climate Influence).

4.3. Lightning

In this type of accident is also observed (tables 5 and 6) a greater concentration of occurrences of men. This fact can also be explained by cultural and socio-economic factors, as this type of event occurs mainly in rural areas where, in Brazil, the concentration of male workers is higher than females, besides most men underestimate the risks more than women.

Table 5: Fatal victims of lightning: preliminary analysis of gender and age

Age (years)	Male					Female				
	Cases		Population		Ratio	Cases		Population		Ratio
	No.	%	No.	%		No.	%	No.	%	
0 - 14	1	2.1%	4,506,645	10.9%	0.2	2	4.2%	4,354,273	10.6%	0.4
15 - 24	6	12.5%	3,502,704	8.5%	1.5	3	6.3%	3,438,892	8.3%	0.7
25 - 59	27	56.3%	10,004,998	24.2%	2.3	6	12.5%	10,683,251	25.9%	0.5
> 60	2	4.2%	2,063,526	5.0%	0.8	1	2.1%	2,707,910	6.6%	0.3
Total	36	75.0%	20,077,873	48.7%	1.5	12	25.0%	21,184,326	51.3%	0.5

n = 48 cases, p = 41,262,199 total habitants. Ratio = $cases_{\%}/population_{\%}$

Table 6: Fatal victims of lightning: preliminary analysis of cities' sizes

City size (resident habitants)	**Cases**		**Population**		**Ratio**
	No.	%	No.	%	
<100,000 (570 cities)	27	33.3%	10,438,191	25.3%	2.2
100,001-500,000 (66 cities)	15	28.2%	14,172,516	34.3%	0.9
500,001-10,000,000 (8 cities)	4	11.5%	5,992,106	14.5%	0.6
>10,000,000 (Sao Paulo only)	2	26.9%	10,659,386	25.8%	0.2
Total	48	100.0%	41,262,199	100.0%	

n = 48 cases, p = 41,262,199 total habitants. Ratio = $cases_{\%}/population_{\%}$

Crossing the location of the fatal victims with demographic census of the IBGE 2010, it was found that in cities with less than 100 000 inhabitants, where 25% of the state population lives, there were 56% of victims of lightning. Yet the city of Sao Paulo has 27% of the state population and accounts for 4% of victims of lightning. The vulnerability of the inhabitants of small towns can be explained by greater permanence in open areas, where it is harder to find shelters during storms, while in São Paulo there is a large concentration of lightning rods.

The number of occurrences of lightning in the State of Sao Paulo is significant. In the first 20 days of 2012, there had been 109,680 lightning all over the state (INPE, 2012), causing material damages and deaths mainly of rural workers.

Figure 5 presents the location of the victims. As floods, it is observed that the victims are in all the state.

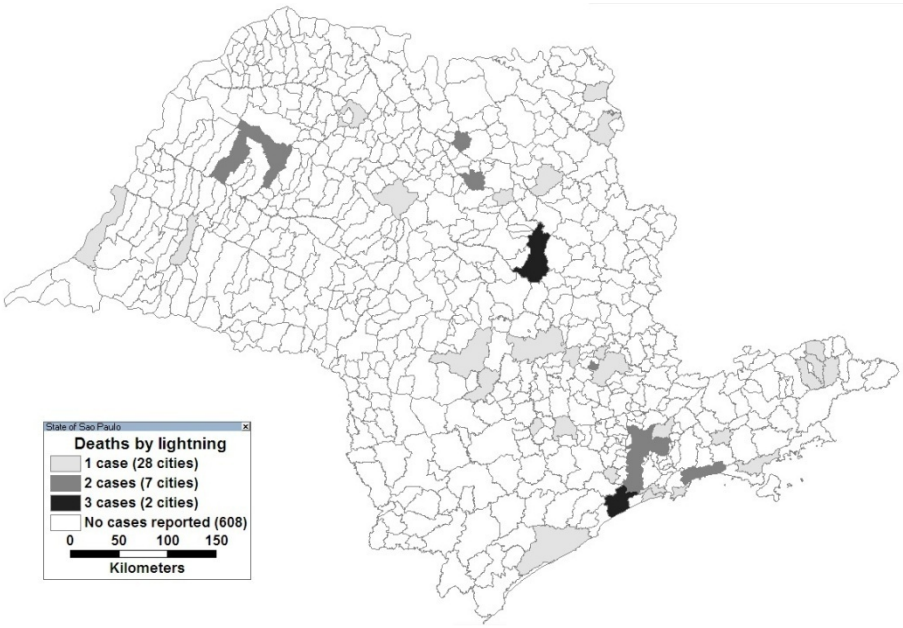

Figure 5:. Location of fatal victims of lightnings

The results of multivariate logit regression confirm the influence of gender, as observed in the preliminary analysis. Women (OR = 2.02) have less probability to be victims of lightning. The strong influence of age: Youth (OR = 3.69) and Adult (OR = 2.22) was also confirmed. The La Nina climate regime also had high influence in lightning occurrences (OR = 2.66).

For the lightning events, the variables of references were: Female (Gender); Elderly (Age); March/April (Month); None (Climate Influence).

4.4. Collapse

The reduced amount of data did not allow preliminary or multivariate analysis on this type of accident. There were only 15 occurrences in the period. Figure 6 presents the location of the victims.

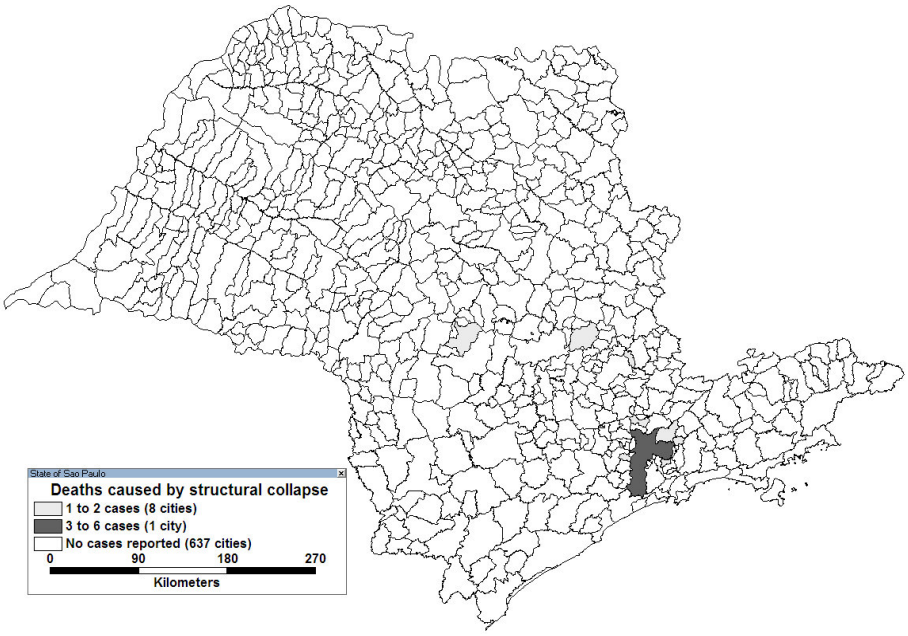

Figure 6:. Location of fatal victims of collapse.

5. Conclusion

This paper presented an analysis of the population affected by natural disasters in Brazil, considering age, gender, and geographical characteristics of victims.

The data of fatal victims were provided by the Brazilian Civil Defense were and crossed with demographic and geographic public information, in order to identify the population

segments under the highest risks of death in a disaster. Logistic regression was applied to quantify the relevance of different factors (age, gender, data, and location).

Shortly, it was observed that the most vulnerable population groups depend on the type of accident or disaster, as follows:

- Landslides: female children (0-14 years); inhabitants of municipalities settled in mountain regions. Rainy season significant month: January.
- Floods: male and less probability of childern.
- Lightning: male adults (25-60 years); municipalities with less than 100,000 inhabitants.

Civil Defense organs can thus use these facts to conduct training and orientation tasks more effectively in order to conduct preparedness activities for future disasters, especially when there is forecasting climatic events. Considering the illiterate population, the illustrations on orientation pamphlets may be adapted to picture representing the most vulnerable social groups. These can also be evidenced in public alerts spread by the media. Future studies could either extend this work to other Brazilian States or other countries. Comparisons of the affected populations in different countries may provide an interesting guide to humanitarian logistics practitioners.

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