Identifying socioeconomic and demographic heterogeneities in displaced populations from urban risk areas: a study case for Belo Horizonte, Brazil

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Abstract

Every year millions of people are displaced due to weather-related extreme events such as floods, landslides and heavy rains. In Belo Horizonte, one of the capitals of southeast Brazil, nearly 390 thousand people live in areas classified as "at risk", areas prone to disaster risk and often occupied by vulnerable communities. The city also has a policy to relocate people living under the exposure of hydrogeological risk in such areas. Therefore, this paper aims to identify and analyze distinct profiles in a displaced population from areas at high risk of disasters in Belo Horizonte. Data were taken from the municipal registers of relocation of Belo Horizonte (2010-2019) including information about demographic and economic characteristics from each household relocated during rainy season. The cluster analysis found eight clusters with different socioeconomic profiles.

Keywords: displacement, disasters, vulnerability

INTRODUCTION

Every year millions of people are displaced due to weather-related extreme events such as floods, landslides, and heavy rains (IDMC, 2021). Climate change, intensified by human action, it's already increasing the occurrence of disasters worldwide, putting thousands of lives at risk in the most diverse environments (IPCC, 2021). However, urban centers tend to be considered hotspots of disasters, due to high populational density, socioeconomic inequality and precarious public services (Pelling, 2003). In Brazil it is not different. Around 8 million people live in areas classified as "at risk", areas that are exposed to extreme events and other external shocks related to weather and climate hazards. In those areas, events such as floods and mudslides can cause human and material losses, displacing large groups of people that are already socially and economically vulnerable (IBGE, 2018).

In Belo Horizonte, the sixth most populous city in Brazil, nearly 390,000 people live in areas prone to disasters such as floods, landslides, and other events related to rainfall patterns (IBGE, 2018). The city has a municipal policy of relocation that aims to resettle people that live

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in these areas to other areas where the environmental risk is mitigated. From 2010 to 2020 almost 1500 households were relocated from vulnerable neighborhoods in Belo Horizonte.

Therefore the research question that this paper aims to answer is: which subgroups are among the resettled through the municipal relocation policy?

Such an approach may be useful for thinking relocation policies and to identify and analyze distinct profiles in a displaced population from areas at high risk of disasters in Belo Horizonte, Brazil, according to socioeconomic and demographic characteristics.

This paper is organized in four sections beyond this introduction. The next session debates the existing literature in population and environment and further about relocation and vulnerability. The following section discusses the methodological approach, followed by the main findings and the conclusion.

Vulnerability, Disasters And Urban Policies

The most recent IPCC report (2021) alerts for an increase in the frequency of disasters related to extreme events and slow onset processes throughout the world in the coming years. Also, climate change and its effects tend to increase the pressure on vulnerable groups and places prone to disaster risk.

The definition of disasters goes through the effects and impacts of the interaction of extreme weather events, those that occur near the upper and lower limits of climatic variables for a given time or period of the year, and, vulnerable social groups, including flash floods, debris-flow, landslides and heatwaves (Lavell et al, 2012). Among the most impacted places, urban centers appear as disasters epicenters due to a conjunction of factors such as: accentuated socioeconomic inequality, restricted access to public services for certain groups, high demographic density accompanied by population growth, and rapid expansion of informal settlements (Pelling, 2003).

Scientific evidence by the IPCC (2014) suggests that human activities play a major role in exacerbating the effects of climate, which would be primarily natural, but have been increasingly frequent and extreme. The trend for Brazil in the coming years is that disasters happen more recurrently, intensity and volume of precipitation that will occur with less predictability, followed by periods of more intense drought that could impact production processes related to the availability of food and water and the well-being of populations in urban centers (IPCC, 2014; Magrin et al, 2014).

Other dimensions of analysis require attention when researching disasters. Wisner (2004) states that disasters must be disconnected from the natural scope in order to understand the social scope of the theme. The risk and vulnerability intrinsic to populations and communities affected

by disasters must be perceived as part of the problem and as a way of reproducing the economic characteristics and patterns to which individuals are subjected. The study of disasters, and especially the multidisciplinary and multi-scale understanding of their consequences, must include a social, economic and demographic perspective on the subject (Pelling, 2003).

Approaches related to vulnerability constantly connect socioeconomic characteristics of populations and their degree of exposure to some environmental or climatic adversity. Therefore, it is important to understand how situations of vulnerability are created and who are the groups relegated to that situation. Kelman (2020) argues that environmental vulnerability is, in most cases, accompanied by social vulnerabilities. Socioeconomically neglected populations due to the lack of housing and infrastructure policies mean that unsafe areas are occupied by poorer groups with less access to public services. In this way, the disaster is socially constructed since these areas tend to consist of steep slopes and river banks mainly in the urban environment (Kelman, 2020; Pelling, 2003).

Furthermore, in addition to socially produced inequalities, among the vulnerable subgroups some will be more impacted than others due to their inherent characteristics, such as income, family composition, and education (Muttarak et al, 2016). This differential in vulnerability between groups is better specified in studies such as Muttarak, Lutz, and Jiang (2016), where the presence of specific socioeconomic characteristics would be able to define degrees of vulnerability among individuals in the same community, making some more susceptible than others to environmental disasters and thus interfering with the migration decision-making process.

Evidence shows that those with more years of education are better prepared for the possibility of disasters (Hoffman & Muttarak, 2017; Muttarak & Lutz, 2014), other variables such as gender of the reference person in households, single-parent families and especially single-parent households with heads females are more vulnerable to disasters than their peers with nuclear families according to studies by Flatø, Muttarak and Pelser (2016) in South Africa, this is because disasters tend to reinforce the existing gender disparities and their relationship with the income. Cultural aspects such as norms, beliefs and values appear in studies of Flavell, Melde and Millan (2020) for specific disasters, such as the cases of disasters related to floods in Bangladesh and Hurricane Mitch in the United States. In the first, women accounted for around 90% of deaths due to men's failure to communicate evacuation notices and the impossibility of leaving their homes unaccompanied by their husbands. In the second case, men, by assuming greater risk behaviors, became more vulnerable when trying to help others. It is already known that elders tend to be more vulnerable to extreme events such as storms, heatwaves, and icy conditions due to a combination

of lack of coping resources, isolation, and difficult mobility (Bunker et al, 2016; Cornell, 2015; Rhoades, Gruber and Horton, 2018).

Therefore, among those in a vulnerable situation, some, being in conditions of greater vulnerability than others, can adapt in some other way, or not adapt at all. According to the literature on population and environment, in cases of migration related to weather events, it is observed that subgroups can get "trapped" in regions prone to disaster risk due to the lack of resources and policies that facilitate mobility in these conditions (Nawrotzki, De Waard, 2017etc.).

In a context where the impacts of climate change are already happening and displacing people, integrating climate adaptation measures into urban planning is necessary so that actions, plans, and programs aimed at prevention mitigate the effects of future disasters.

Cities play a central role in adapting to climate change both because of the presence of threats and their social and economic context. Cities concentrate approximately 55% of the world population (UN, 2018). In Brazil, more than 80% of the population lives in urban environment (IBGE, 2010). This scenario tends to increase with the continuous process of rural-urban transition that takes place globally, thus, urban agglomerations tend to concentrate more people in less sparse locations and with serious environmental problems caused by disorderly expansion and accentuated economic inequality. Therefore, knowing the demographic characteristics and socioeconomic profile of the ones living in areas at risk can enhance the knowledge about who they are and how policies can be better designed.

If in one hand cities can be considered hotspots for disasters, on the other hand, large cities can display a leadership role due to the concentration of economic and political resources. These resources can mobilize actors and important key players in the formulation of urban policies for adaptation and mitigation. In urban policies, mainly municipal, the approach tends to be top-bottom and reactive when it comes to climate change. Policymakers define objectives and goals after an external shock happened and citizens have already been affected without consulting stakeholders that can take the most advantage through them and benefit from its further prospects.

As an example, the Structural Program of Risk of Belo Horizonte is part of a policy that was developed after informal settlements were hit by floods in the late 1990s. The policy offers a range of actions for the ones living in areas at risk such as inspections, house reforms, temporary and permanent relocation. Besides, the program counts on volunteers from those areas to help with the surveillance of houses in deprived conditions and city hall agents that make the inspections together with members from the Civil Defense.

The program has two assistance centers composed of those volunteers and city hall agents: the Civil Defense Nucleus Training (NUDEC) and the Rain Alert Nucleus Training (NAC). Both

nuclei monitor rainfall levels in the city and make the contact between population and city hall. During the rainy season, the program's activities include the dissemination of educational booklets, guidance on prevention and evacuation in case of disasters, and training with volunteers (PBH, 2020).

Once the risk is detected, by the inhabitants or the volunteers, an inspection with agents from city hall and Civil Defense is scheduled to evaluate the degree of the risk. In cases of risk of eminent landslip or exposure to floods and heavy rains the family has two options through the municipal policy: leave the house temporarily or permanently.

In case of a temporary relocation, the family leaves the house for a determined period of time, that lasts on average 3 months, to another place living with financial assistance from the city hall. After that period, they return to their houses. In case of permanent relocation, the entire family is removed to buildings constructed by the prefecture to shelter families previously exposed to disaster risk. In some cases, when families resist to leave the areas at risk, the City Hall agents use tools such as bargaining and financial compensation to convince people to leave their houses.

With this in mind, there is an increasing need for cities committed to urban policies capable of identifying and assisting those in vulnerable situations with proposals aimed at adapting to the impact of disasters and mitigating risks.

Data & Methods

Using data from the registers of temporary and permanent relocation made from 2010 to 2019 we will set up a database for the hierarchical clustering analysis. Municipal urban policy is managed by the Urbanization and Housing Company of Belo Horizonte (URBEL) which provided the data that made this research feasible. Data contains information about each of the individuals and households relocated in this period. These variables can be assessed to describe the household socioeconomic conditions and demographic family composition, profiling their social vulnerability and, understand who the policy has been atending in the recent years.

The variables considered in the analysis are listed in table 1:

Table 1 – Household Head Information

Variable	*Category*	*Sample (N)*
Households		748
Sex	Male	45.9%
	Female	54.1%
Education	No Formal Education	9.8%
	Primary Education	62.2%
	Secondary Education	22.5%
Occupational Status	Employed	37.5%
	Unemployed	16.6%
	Retired	8.3%
	Stay-at-home	10.8%
	Self-employed	12%

Labor Contract	Informal Worker	12.1%
	Employer	1.3%
	Formal Contract	38.5%
	Informal Contract	2.3%
	No Answer	59%

Source: Elaborated by the authors

Even though the variable Labor Contract has a high rate of no answer, the variable was maintained to crosscheck the answers for occupational status and the occurrence of this type of answer to certain clusters. In addition to the categorical variables described above, numerical variables such as Number of Members in the Household, Number of Children in the Household, Age, Total Household Income and Income Per Capita were also considered. In the case of variables related to income, all values were deflated to values of 2020.

Using the information about family composition, five variables were created to describe each household according to its characteristics as seen in table 2:

Table 2 – Categoric variables to describe household

Variable	*Category*	*N*
Has people under 15 years old	Yes	60.2%
	No	39.8%
Has people over 65 years old	Yes	8%
	No	92%
Has Partner living with household head	Yes	50.9%
	No	49.1%
Has Cash Transfer Program	Yes	23.2%
	No	76.8%
Has Extended Family	Yes	13.2%
	No	86.8%

Source: Elaborated by the authors

Cluster analysis can segment observations grouping the most similar and separating the different. Through successive iterations, the hierarchical clustering technique allows exploratory observations in data. Although is a good method to describe specific populations it may not be able to generalize results to other populations.

Using the agglomerative approach, the clusters are assembled from the bottom to the top, where each observation is grouped with the other ones that convergence in terms of distance from each medoid of the formed clusters.

With the elbow method to set the number of clusters, due to its capacity to divide clusters based on their similarities, 8 were suggested by the algorithm with a 30 value of the sum of squares (ss). Through the agglomerative approach, eight clusters were found and, will be characterized in the next session. For descriptive purposes, the numerical variables were considered the mean value for the cluster, except for Age, when it was considered the median to avoid biases due to outliers of advanced ages.

Results

An estimation of 8 clusters was the best fit for the database through the elbow method. After that, the procedure to clustering took into account only households where the data was complete for all the considered variables. For that, the number of households fell from 787 to 748. The results for each cluster are shown in table 3:

Table 3 – Clusters Characteristics

Characteristics	*Cluster 1 N=42*	*Cluster 2 N=176*	*Cluster 3 N=163*	*Cluster 4 N=185*	*Cluster 5 N=88*	*Cluster 6 N=26*	*Cluster 7 N=54*	*Cluster 8 N=14*
Prop. of female headed households	66%	20.4%	60.7%	50.8%	64.7%	92.3%	100%	78.5%
Prop. of households of extended familes	2.3%	0.5%	17.7%	2.7%	14.7%	100%	42.5%	35.7%
Prop. of households with inhabitants with age < 15 years old	0%	19.8%	99.3%	100%	2.2%	80.7%	100%	21.4%
Prop. of households with inhabitants with age > 65 years old	50%	1.1%	1.2%	0.5%	5.6%	34.6%	1.8%	92.8%
Prop. of households with partners living with household heads	19%	69.3%	55.8%	72.9%	11.3%	15.3%	5.5%	100%
Median Age of Household Head	61	37.5	34	31	43.5	56.5	43.5	64
Mean income per capita	R$ 697.5	R$ 649.1	R$ 414	R$ 306.3	R$ 861.4	R$ 406.9	R$ 240	R$651.4
Mean total income	R$ 1406.9	R$1603.4	R$1716	R$ 1289.3	R$ 1664.5	R$ 1836.6	R$ 1064.3	R$ 1890
Mean number of people living in the household	2.1	2.8	4.5	4.43	2.4	5	4.9	3.5
Mean number of children living in the household	0	0.3	2.1	2.3	0	1.4	2.4	0.42
Prop. of households with Cash Transfer Programs (CTP)	14.2%	6.8%	33.1%	32.4%	14.7%	7.6%	42.5%	7%
Prop. of households where the household head has no formal education	64.2%	2.8%	5.5%	4.8%	2.2%	50%	7.4%	42.8%
Prop. of households where the household head has primary education	26.1%	59.6%	69.3%	64.8%	69.3%	50%	76%	50%
Prop. of households where the household head has at least secondary education	7.1%	25.5%	25.1%	29.1%	25%	0%	16%	0%
Prop. of household heads employed	0%	39.2%	99.3%	1%	65.9%	0%	0%	0%

Prop. of household heads unemployed	7.1%	16.4%	0.6%	32.4%	11.3%	0%	31.4%	7.1%
Prop. of household heads retired	40.4%	5.6%	0%	4.3%	2.2%	19.2%	11.1%	78.5%
Prop. of household heads stay-at-home	26.1%	2.2%	0%	15.6%	5.6%	77%	16.6%	14.2%
Prop. of household heads informal workers	4.4%	15.3%	0%	26.4%	5.6%	3.8%	9.2%	0%
Prop. of household heads self-employed	7.1%	15.3%	0%	20%	8%	0%	29.6%	0%
Prop. of household head with formal contract	0%	37%	99.3%	1.6%	72.7%	0%	1.85%	0%
Prop. of household head with informal contract	0%	5.6%	0.7%	1.6%	0%	0%	0%	0%
Prop. of household head with no information	100%	57.4%	0%	96.7%	27.2%	100%	98.1%	100%

Source: Elaborated by the authors

Cluster 1 is characterized by a majority of women over 60 years old heading households living alone or at least with one more person. It's the second cluster with the highest rate of retired household heads and with no formal education mostly. These households have an average income per capita of R$ 697.50.

Cluster 2 is characterized by a majority of men heading households with a median age of 37 years old living. Those men live mostly with children and partners and their majority have primary education. These households have an average income per capita of R$ 649.1. Most of these household heads are employed formally.

Cluster 3 is characterized by a majority of women heading households. These women have a median age of 34 years old and live with partners and children. These households have on average 4.5 members and usually 2 children under 15 years old. These households have an average income per capita of R$ 414. Almost 100% of these household heads are formally employed.

Cluster 4 is the largest. It has the lowest average income per capita, R$306.3. Most household heads are equally divided in male and female and living with children and partners, usually in a 4 people household. Almost 65% of the household heads have primary education and are divided mainly among occupational groups such as informal workers, stay-at-home and self-employed.

Cluster 5 is composed of 88 households. This cluster is characterized by a majority of women head of household living in average with another person, only a minority of household heads in the cluster lives with someone under 15 years old (2.2%), over 65 years old (5.6%), and partner (11.3%). With a median age of 43.5 years old, they have the highest income per capita, R$861.5, 69.3% have primary education, and 65% are formally employed.

Cluster 6 is characterized by a majority of women over 56 years old heading households living with children under 15 years old. 100% of the households in this cluster are composed of extended families. It's the cluster with the highest total income, R$ 1836.6, but one of the lowest income per capita rates, R$406, due to the income transference between generations. In this cluster 50% of household heads have no formal education and 50% have only primary education, also, 77% of them stay at home and almost 20% are retired.

Cluster 7 is characterized entirely by women living with children under 15 years old and has the highest rate of households with some type of financial assistance from the government, 42.5% (cash transfer programs). 42% of the households are composed of extended families and it has the highest average of household members, 4.9. This cluster also has the lowest income per capita, on average R$240 and these women are mostly unemployed or self-employed engaged with activities from the third sector.

Cluster 8 is the smallest cluster, comprising only 14 households that are, mostly, headed by women living with partner and retired. The household heads have a median age of 64 years old, the oldest, 78% are retired and 50% declared having only primary education, and live on average with other 2 people. This cluster has an average income per capita of R$651.4.

Conclusion

The analysis presented in this study has identified 8 types of clusters among the relocated in the city of Belo Horizonte. While clusters 1 and 8 are composed by household heads with advanced age and living in small families, clusters 6 and 7 are composed of extended families living with the lowest income per capita. Clusters 3,4 and 7 have the highest rates of households participating in Cash Transfer Programs from the government, which shows their economic vulnerability.

In terms of family composition, the clusters are very different, we see a majority of families with both parents and children as the biggest part among the relocated and also a group composed essentially by retired and over 60 years old, the last group can be extremely vulnerable in episodes of flash floods or landslips.

In a context of increased frequency of disasters people with less mobility tend to be at a bigger disadvantage when compared to other groups, such as the youngest ones. Other than that, these people are at disadvantage with the general population of the city in terms of income. Most of the households live with an average income per capita that goes from R$ 240 to R$ 860, while the average income of the city in 2020 was R$ 3300 (IBGE, 2020). That shows that in terms of economic resources, these families are at an economic disadvantage.

The policy, attending these types of clusters, can indicate what kind of families inhabit these areas and provide information about these groups and their demographic characteristics. The clusters can also help better describe the groups living in areas at risk and their situation at the moment of the relocation. Besides, their socioeconomic vulnerability, many of these individuals are informal workers with no stable gains or salary, undermining their financial capacity to develop coping resources.

Cluster analysis highlights the different profiles of the relocated groups and how similar they are. However, this methodology aims more to help draw hypotheses than to make assumptions about the analyzed group since different parameters can generate dissimilar results. It is worth exploring why and how clusters are different from each other and examine these subgroups in future research. Thus, delineating better policy responses surrounding disaster displacement, relocation and its implications to people and communities.

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