HEALTH EVALUATION OF THE BARRA LONGA POPULATION AFFECTED BY THE DISASTER IN MARIANA COUNTY[1]

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Introduction

On the evening of November 5th, 2015, Fundão tailing dam, which was operated by Samarco Mining, disrupted in Mariana County, Minas Gerais State (MG). It released 50 million m^3 of iron-mining tailing and caused the biggest mineral environmental disaster in Brazil. A *tsunami* of toxic mud reached Gualaxo do Norte River and Bento Rodrigues district. It devastated the location and, in the following dawn, it reached Carmo River and entered Barra Longa County. The trajectory taken by the toxic mud led it to the mouth of Doce River in Espírito Santo State (ES). At the end, forty counties were reached by the mud in the two states, thus totaling 663Km of directly impacted water bodies. Nineteen casualties were recorded, but thousands of families were displaced and eleven tons of fish ended up dead (IBAMA, 2015; JUSTIÇA GLOBAL, 2015).

Countless disasters involving mineral dams were reported in Brazil and all around the world. Five dams disrupted in MG in the last fifteen years (RIBEIRO, 2015; ESDHC, 2015). According to Recommendation CNZU n. 08/2017 from the National Humidy Zones Committee of Environment Ministry, the herein addressed accident was caused by drainage flaws and by the recoil work on the face of the dam, which features the accident as a technological disaster resulting from human failure. Mining activities generate a huge volume of tailing due to the small concentration of metals found in rough ore and to process inefficiency (ARAUJO, 2006). The toxic mud resulting from this activity may

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present residual amounts of sulfonates, amines and cyanides, besides the used solvents, such as caustic soda and sulfuric acid, as well as heavy metals (GARDEN QUIMICA, 2014; BAIN &COMPANY, 2014), which can be dangerous elements for human health and for the environment (BRASIL, 2011).

According to Brazilian Environment and Renewable Natural Resources Institute - IBAMA (2015), damages to the population health varied from casualties, and wounded victims, to psychological health issues. Population safety after the disaster was a concern, since populations in the affected communities and those living in adjacent areas live with the fear of new disruptions. There was the threat of disease transmission, such as Cinomosis and Leishmaniosis, by severely wounded animals, as well as of habitat disinfection services, and plague and vector control interruption in the first locations reached by the mud. They could become the reproduction spot for vectors of diseases such as Dengue, Schistosomiasis, Chagas Disease, Leishmaniosis, besides the problems with poisonous animals. Surveillance services concerning epidemiological, sanitary, environmental and labor health were canceled, as well as public safety services.

Rocha et al. (2016) recorded expressive increase in diarrhea, fever and skin affection cases in the riverside population from Colatina County/ES. These symptoms were associated with environmental changes, lack of drinking-water supply, water contamination, among others.

Barra Longa County had 5,710 inhabitants back in 2015 (IBGE, 2016). It was the second county to be reached by the giant toxic-mud flow, its streets and houses, crops and breeders were invaded by it (Figure 1).

Based on the magnitude of Barra Longa disaster, the aim of the present study was to identify the perception of the population exposed to the mud about its physical, mental and social health, as well as about the fulfilment of its needs to assure health and well-being, according to self-assessments. Therefore, it is the evaluation of a post-disaster scenario.

The results must guide actions and help policy makers to find the opportunities, the magnitude of possible health risks, and to guide their choices about prime policies and programs focused on reducing damages and preventing the severity of future repercussions.

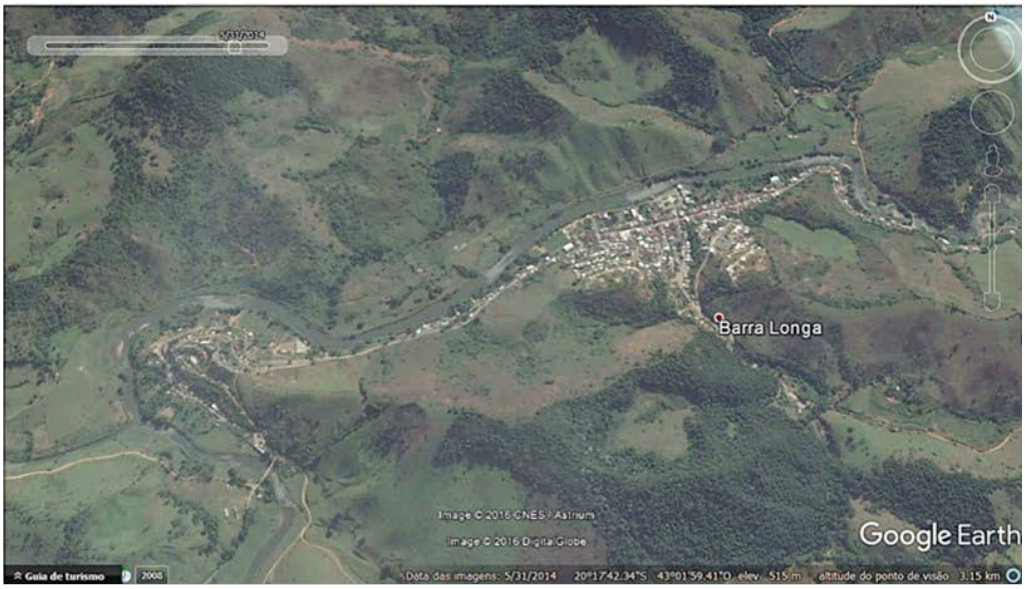
Methodology

It is an exploratory, cross-sectional and descriptive study based on self-assessment interviews about health in a post-disaster scenario. The research was conducted by the Health and Sustainability Institute and approved by the Research Ethics Committee of Moriah Hospital, São Paulo - CAAE Process 56439916.0.0000.8054.Interviewees signed the Free and Informed Consent Form.

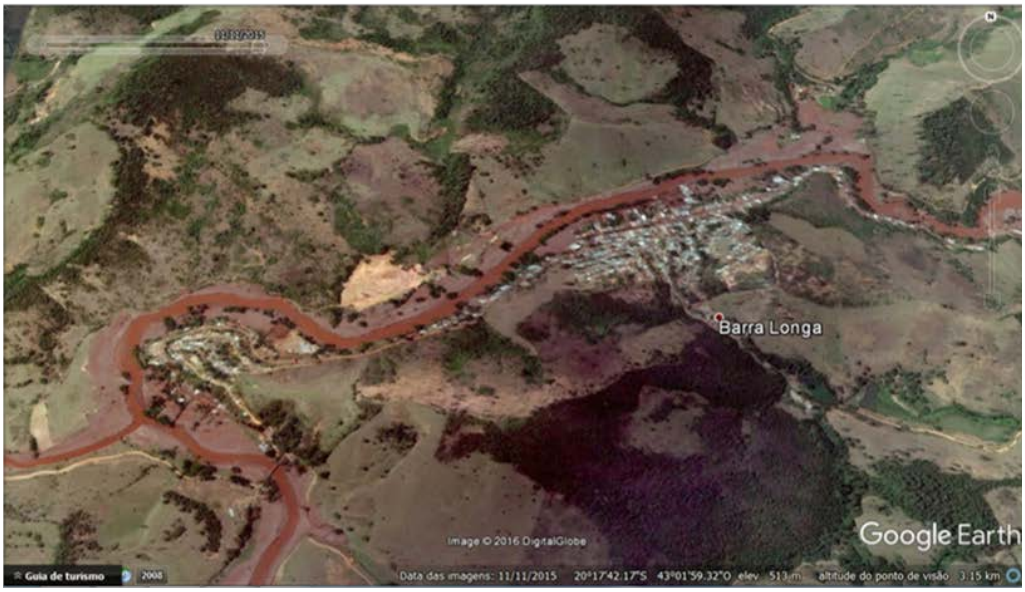
The self-assessment questionnaire about health was elaborated from a series of surveys and documents (USP, 2008; NCHS, 2009; CDC, 2012; WHO, 2012a; WHO, 2012b; IBGE, 2013; IBGE, 2015; UFSC-CEPED, 2012; WHO, 2015; WHO, 2017).

The possible effects of different natural disaster types (OPAS, 2015) on human health were taken into consideration to elaborate the health questionnaire. It would be possible classifying Mariana disaster as a large-scale geo-hydrological landslide and flood disaster if it was caused by natural reasons.

Figure 1. Aerial view of Barra Longa District before and after the disaster



a) Aerial view of Barra Longa before the disaster



b) Aerial view of Barra Longa after the disaster

Source: Google Earth, 2015

It is known that the effect of disasters on public health can come up at different moments: at the Rescue, Recovery and Reconstruction phases. The Rescue phase shows the most acute effects, such as drowning, lesions or death, which can be momentary or emerge within days. The Recovery phase concerns symptoms that come up within weeks and months after the accident, such as infectious diseases - transmissible, or not, by vectors, such as Dengue, Hepatitis A, diarrhea –, intoxication, skin lesions, respiratory diseases, the worsening of chronic diseases - for instance, Hypertension and its consequences –, stroke and heart attack. The Reconstruction is linked to symptoms that emerge within months and years after the disaster, or even, that show up as behavioral disorders, both psychological and mental (FREITAS et al., 2014).

The questionnaire also held signs and symptoms of the exposure to metals and other toxic substances, because the herein addressed disaster involved mineral tailing and the exposure to mud with elements that are toxic to humans (IPCS, 1978; WHO, 2015).

Thus, the questionnaire was elaborated to cover all answers and diseases described above, as well as the inabilities; the behavioral and psychological changes; genetic, immunological, neurological and mental diseases, social aspects and quality of life – relation with work, safety and violence, and with the environment (FREITAS, 2014; OPAS, 2015, WHO, 2015). The aim of the study was not to show symptom differences before and after the disaster through self-reference, since the questionnaire started being applied in October 2016, almost eleven months after the disaster. However, such relation could be better verified in some diseases that were diagnosed and treated before the disaster.

The questionnaire was composed of two modules: 1) questions to identify the families participating in the study, such as questions regarding their housing, schooling and socioeconomic conditions; and 2) personal quantitative and qualitative questions concerning self-referred health condition, diseases and symptoms, access to health services, among others (INSTITUTO SAUDE E SUSTENTABILIDADE, 2017).

The methodology to define the sampled population followed the Bernoulli distribution probability (LEMESHOW et al., 1990). We assumed that all Barra Longa inhabitants were affected by the mud, no matter if they lived, or not, in places invaded by it. We made the decision to add the populations living in urban and rural areas to the sampling group – Barreto and Gesteira (approximately 3,000 inhabitants – half of the affected populations). The population sampling started from listing families assisted by the Family Social Program. The study started from raffling the families, so that respondents would be the set of members composing the families.

The option was made to calculate the samples considering a statistical power of 80%, 5% significance and 5% delta, which resulted in a sample of 350 individuals plus 15% loss, thus totaling 402 individuals. Two individuals per family were taken into consideration to calculate the number of families, since it was necessary having 201 families plus the 25% loss. The final sample comprised 251 families.

Two-hundred families, out of the total invited to participate in the study, accepted the invitation (579 members). All members were invited to answer the personal health questionnaire, 507 of them (87.6%) accepted to participate in the research.

Data were processed in the *Statistical Package for Social Science – SPSS* software, version 15.0 (SPSS, 2009) and subjected to descriptive analysis. Frequencies were extracted from qualitative variables; the central trends and variability were extracted from quantitative variables.

The associations between exposure variables and housing locations (urban area close to the river, downtown area, Volta da Capela neighborhood, and rural area) in the district were tested based on the results of the main symptoms.

The chi-square test was used in the exposure variables with two categories. The Fisher's exact test was applied when at least one casela recorded expected-value lower than five.

Logistic regression models were adjusted in order to test the exposure variables with three or more categories. The significance level used in the analysis was set at 5%.

The questionnaires were tested previously to the interview.

Results

The majority of population participating in the study knew the environmental degradation it was exposed to. Sixty-one percent (61%) of the sample stated to be exposed to some contaminated site, or contamination source, located close to their homes, and 55% of them said to be exposed to dusty air.

The sample was composed of 26 households (11.7%) located in rural areas (Barreto and Gesteira), and of 197 (88.3%) houses in urban areas –downtown (46.6%) and close to the riverbed (41.7%).

Members of the interviewed families had low schooling, 63% of them only finished the elementary school.

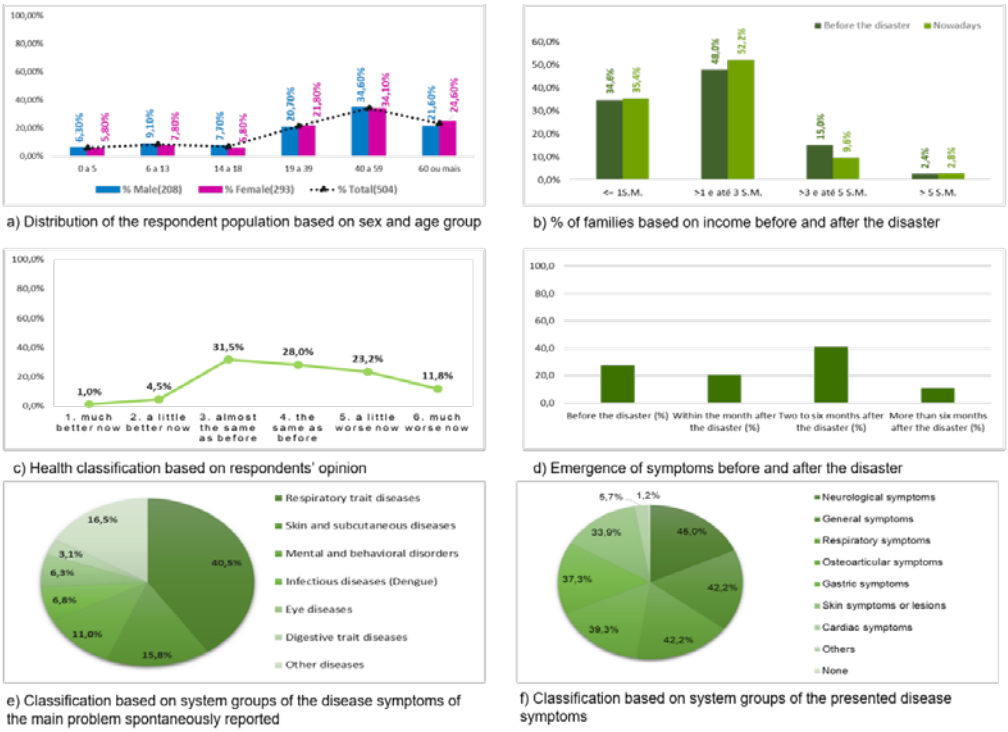
Monthly family income was three minimum wages, on average, in 87% of the families. The comparison between information provided by the families about their current and past incomes showed that 76.5% of the them remain in the same social class and that 15.7% lost some of their incomes (Figure 2b).

Two-hundred and ten respondents (41.7%) were men and two-hundred ninety--four (58.3%) were women. Distribution based on age group can be seen in Figure 2a.

When adult and adolescent individuals were asked about their opinion on their own health condition since the disaster, 35% of them believed their health was much worse or little worse now; 59.9% reported almost the same or equal health condition; and 5.5% stated to be better or a little better than before the disaster (Figure 2c).

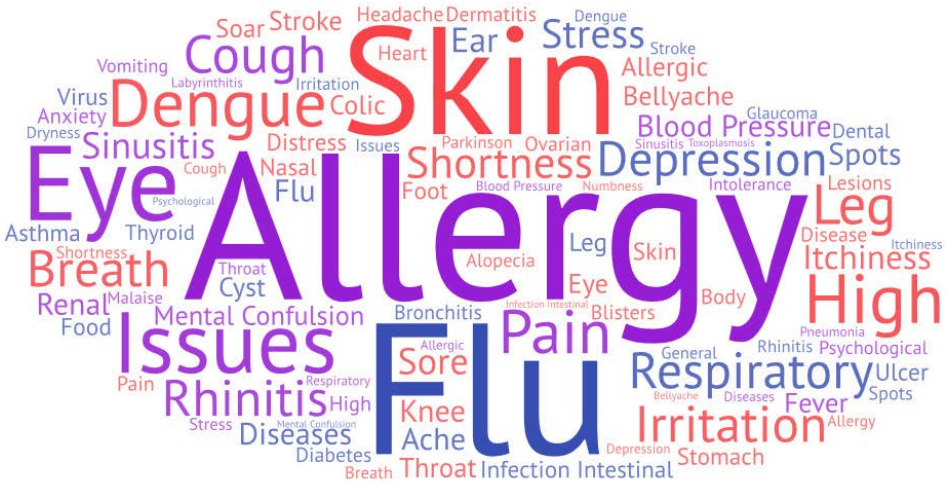
Participants were asked to answer whether they have had any health issue since the disaster; 43.5% of them were positive to it. Interviewees spontaneously mentioned their health issues. In case they presented more than one health issue, they should chose the main one or the one causing more discomfort. The diagram in Figure 3 reproduces interviewees' narratives: the larger the number of equally reported complains, the more significant their representation in the diagram.

Figure 2. Information about the results



Source: adapted from Health and Sustainability Institute, 2017

Figure 3. Diagram of spontaneous words defining the health issues



Source: Health and Sustainability Institute, 2017.

Among spontaneously reported issues, 40% were respiratory diseases, 15.8% were skin conditions, 11% were mental and behavioral disorders, 6.8% were infectious diseases, 6.3% were eye diseases and 3.1% were gastric and intestinal diseases (Figure 2e). Respiratory diseases accounted for 60% of children (from 0 to 13 complete years) complaints.

Among respondents who have reported health issues since the disaster, 56% stated to have stopped performing some common and domestic activities, and 49.5% gave up fighting, fact that evidences an important and limiting impact.

We took the appropriate care to show some symptoms to the interviewees, since they could not have some disease diagnostics: 66 physical symptoms, which referred to symptoms that had emerged after the disaster. The total of 396 respondents referred to one or more physical symptoms – 77.9% of the population (507).

Table 1 shows the symptoms classified according to their frequency. The fifteen first symptoms are highlighted in yellow.

According to the table above, the three most cited symptoms were headache (28.6%), cough (27%) and leg pain (23.9%), which were followed by anxiety (20.9%), itchiness (20.5%), skin allergy (18.11%), blunt (17.9%), fever (15.4%), respiratory allergy (15.4%), coryza (14.6%), cramps (13.6%), asthma, lack of appetite, diarrhea and weight loss.

Respondents were asked to choose the five main symptoms among all the reported ones. The result has shown that the same symptoms reported above were the most important for the respondents; moreover, their frequency was also quite similar to the previously reported. Leg pain ranked second, it came right after headache.

Neurological symptoms (45%) were the most prevalent among all grouped systems. These symptoms were followed by gastric and intestinal (37.3%), and skin symptoms (33.9%) (Figure 2f). The respiratory and general symptoms would be the main ones if we excluded the headache and anxiety symptoms from the neurological group.

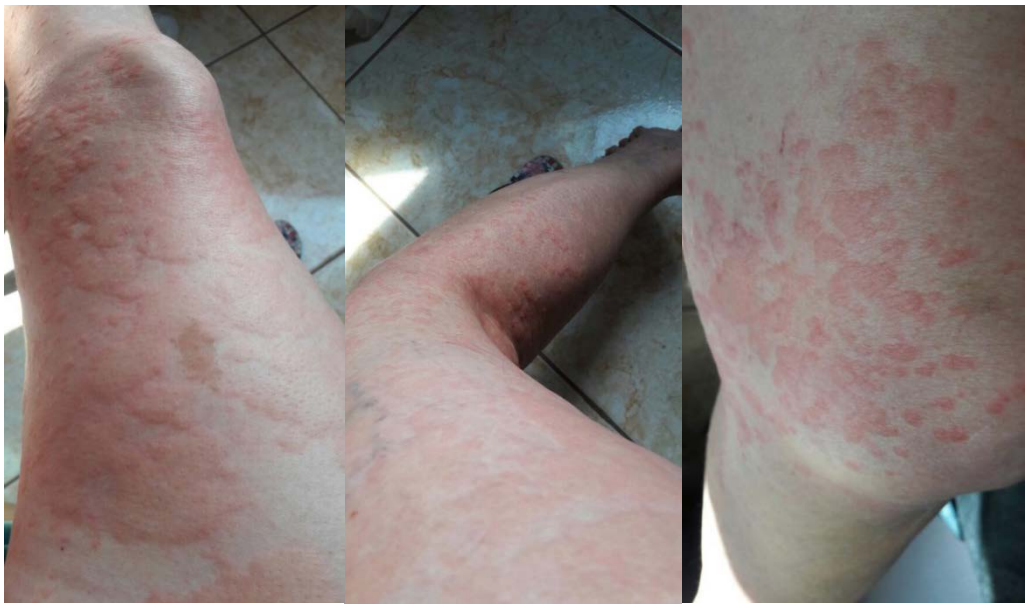
Skin diseases called the attention and were reported by the population in Barra Longa with wrath. Maculo-erythematous, pruritic and scaly lesions were the most common ones. They can be characterized by vesicles and blisters, as well as by burning sensation (Figure 4).

Table 1 – Set of reported physical symptoms

	Symptoms	Total county	% reports (2385)	% sample (507)	% Resp (396)	Ranking
Gerais	Blunt	91	3,8	17,9	23,0	7
	Anemia	23	1,0	4,5	5,8	33,0
	General malaise	53	2,2	10,5	13,4	17,0
	Weight loss	55	2,3	10,8	13,9	16,0
	Sweating	18	0,8	3,6	4,5	39,0
	Weakness and fatigue	33	1,4	6,5	8,3	28,0
	Fever	78	3,3	15,4	19,7	9,0
Osteoarticular symptons	Greater muscle sensitivity	50	2,1	9,9	12,6	19
	Muscle tiredness or lack of strength	47	2,0	9,3	11,9	21
	Light shaking	19	0,8	3,7	4,8	38
	Leg pain	121	5,1	23,9	30,6	3
	Cramps	69	2,9	13,6	17,4	12
	Pain in the joints	44	1,8	8,7	11,1	22
	Pain in the bones	42	1,8	8,3	10,6	24
	Osteoporosis	8	0,3	1,6	2,0	49
Gastric Systems	Anorexia	0	0,0	0,0	0,0	64
	Lack of appetite	61	2,6	12,0	15,4	14
	Nausea	48	2,0	9,5	12,1	15,4
	Vomiting	52	2,2	10,3	13,1	18
	Abdominal discomfort	32	1,3	6,3	8,1	29
	Indigestion	14	0,6	2,8	3,5	44
	Abdominal cramps	22	0,9	4,3	5,6	34
	Gastritis or stomach ache	44	1,8	8,7	11,1	22
	Diarrhea	58	2,4	11,4	14,6	15
	Intestinal constipation	11	0,5	2,2	2,8	46
	Blood in the feces	5	0,2	1,0	1,3	532
Skin Symptons or Lesions	Skin allergy	92	3,9	18,1	23,2	6
	Skin ulcerations	6	0,3	1,2	1,5	50
	Different eruptions	15	0,6	3,0	3,8	43
	Itchiness	104	4,4	20,5	26,3	5
	Rash	24	1,0	4,7	6,1	31
	Spread rash lesions	16	0,7	3,2	4,0	42
	Folliculitis	2	0,1	0,4	0,5	61
	Pyoderma, lesions with pus	3	0,1	0,6	0,8	58
	Atopic eczema	0	0,0	0,0	0,0	64
	Papules or small lesions	4	0,2	0,8	1,0	55
	Vesicles or blisters	4	0,2	0,8	1,0	55
	Herpetic lesions	1	0,0	0,2	0,3	63
	Peeling	10	0,4	2,0	2,5	47
	Palmar and plantar peeling	18	0,8	3,6	4,5	39
	Hair loss	41	1,7	8,1	10,4	25
Cardiac Symptons	Pulse weakness	9	0,4	1,8	2,3	48
	Fast heart beating	22	0,9	4,3	5,6	34
Respiratory symptoms and diseases	Nasal bleeding	13	0,5	2,6	3,3	45
	Respiratory allergies	78	3,3	15,4	19,7	9
	Cough	137	5,7	27,0	34,6	2
	Asthma	62	2,6	12,2	15,7	13
	Pain in the chest	27	1,1	5,3	6,8	30
	Coryza	74	3,1	14,6	18,7	11
	Pharyngitis	21	0,9	4,1	5,3	37
	Laryngitis	3	0,1	0,6	0,8	58
	Pneumonia	3	0,1	0,6	0,8	58
	Brochitis	24	1,0	4,7	6,1	31
	Bronchiolitis	0	0,0	0,0	0,0	64
Neorological symptoms	Head ache	145	6,1	28,6	36,6	1
	Visual disturbances	18	0,8	3,6	4,5	39
	Vertigo	39	1,6	7,7	9,8	26
	Insomnia	83	3,5	16,4	21,0	8
	Muddy behavior	38	1,6	7,5	9,6	27
	Anxiety	106	4,4	20,9	26,8	4
	Fainting	5	0,2	1,0	1,3	53
	Convulsion	4	0,2	0,8	1,0	55
	Loss of sensibility	6	0,3	1,2	1,5	50
	Loss of smell	6	0,3	1,2	1,5	50
	Mar	2	0,1	0,4	0,5	61
Others	Some other health condition symptom	22	0,9	4,3	5,6	34
Total		2385	100,0			

Source: Heath and Sustainability Institute, 2017

Figure 4. Skin diseases reported by the interviewees



Source: Health and Sustainability Institute, 2017

Twenty-seven point five percent (27.5%) of the listed symptoms started before the disaster and 72.3% of them were observed after it – 20.4% within the month of the disaster. The highest record (41%) of them was observed from 2 to 6 months after the disaster and 10.9% of them were recorded more than 6 months after it (Figure 2d).

According to the respondents, the first symptom reported by them, which is the most important one, disappeared after the disaster in 28% of the cases; it became recurrent in 40% of the cases, changed in 15%, got better in 12% and got worse in 6% of the cases. Respondents were assisted by a health professional in 90% of the cases.

It is worth highlighting what happens with Volta da Capela urban area residents – 66 participants (13%) live in this neighborhood. Almost all families living in this area have income close to one minimum wage – the region has the lowest income rates. Moreover, 65.2% of this population is composed of women – the highest index in comparison to the other neighborhoods. This neighborhood also holds the highest concentration of children and adolescents.

Assumingly, it is the population most vulnerable to the effect of environmental contamination. The location chosen to store the mud collected from the downtown area recorded the strongest exposure rates. This location is close to the riverbed and was totally destroyed by the mud. It also presents the highest air pollution level per particulate (as evidenced by the quality of the air monitoring). The number of children and adolescents (one of the populations more susceptible to air pollution) is almost two times larger than that of other regions. The answers given by the group living in Volta da Capela were compared to the ones provided by individuals living in

other parts of the county. The analysis was performed in order to assess whether the observed differences were statistically significant – the chosen model is appropriate to test associations between exposure (residence location) and outcome (symptom). Assumingly, respondents living in Volta da Capela have more chances to have skin disease symptoms and cramps than the ones living in rural areas, as well as more leg and bone pain than the ones living in urban areas. They have more chances to have vomiting symptoms than individuals living in urban areas close to the river. The tested non-significant variables were cough, anxiety, insomnia, pain in the joints and nausea. Different residence locations can be associated with different outcomes. Test results have shown that the statements based on descriptive analysis (frequencies and proportions) have little chance to be wrong.

Data about environmental equity suggest that urban subpopulations, often the low socioeconomic level groups, are consistently more exposed to higher pollutant concentrations due to local sources of it. These groups are also more susceptible to the effects of these pollutants and can have a harder time adapting to the impairments caused by them (WHO, 2006).Individuals who have less resources are the ones who have a harder time adapting; therefore, they are the most vulnerable ones – the less resilient population. It is exactly what happens in Volta da Capela, since the population demanding more monitoring over their risks and health conditions lives in there.

When interviewees were asked about the diagnosis of diseases informed by a health professional, it was possible noticing that:

About the respiratory diseases: the 89 flu cases (17.8%) and 45 coryza or chronic sinusitis cases (8.9%) might be explained by air pollution. Asthma was reported by 11 individuals; emphysema, chronic bronchitis and other acquired chronic lung diseases were reported by 7 individuals. Individuals living in rural areas basically did not present the described respiratory diseases.

With regard to infectious diseases: there was a Dengue outbreak (6.6% of the population) reported, from 2 to 6 months after the disaster, but just in the urban area. The outbreak was notified by the Municipal Health Bureau in February and March 2016. One case of Zika, Schistosomiasis, Chagas and Leishmaniasis were also recorded. There was no report on Hepatitis A, Chikungunya and Leptospirosis.

Cardiac disease and diabetes diagnoses were reported by 36.9% of the population. People living in rural areas and in Volta da Capela proportionally presented more hypertension cases (29%) than the ones living in urban areas (24%). There was less diabetes cases in the rural area than in the urban one. Volta da Capela recorded the highest diabetes prevalence (9.1%).

With regard to emotional and behavioral symptoms (20): 423 individuals (83.4% of the interviewees) reported to have them.

Insomnia was the most frequent symptom (187 reports, 36.9% of the assessed population), which was followed by stress (21.7%), sadness (18.1%), constant fright (17.8%), mood changes, anger or aggressiveness (15.6%),frequent crying (12.6%), hard time making decisions (10.5%), apathy (10.1%) or drowsiness (9.5%). Such indices highlight that Barra Longa population was psychologically affected by the disaster.

Insomnia prevalence was reported in all ages: 19% of children between 6 and 13 years, 20.6% of adolescents, 36.4% of adults from 19 to 39 years, and 42% of adults older than 40 years, including elderly. Insomnia is diagnosed when the person has a hard time falling asleep and/or to keep on sleeping.

About the reported diagnosis of some mental or neurological disease: the number of positive anxiety disorder, stress and depression episodes was noteworthy (23% of the respondents).

Anxiety was reported by 10.6% of the respondents, and 80% of them were reported by women; 48.1% by individuals in the age group from 40 to 59 years. Most individuals reported that the symptoms started before the disaster (66%) and 34% reported them to have started after the disaster. Fifty-six point three percent (56.3%) of the cases observed before the disaster reported to have gotten worse after it. Eighty-one percent (81%) of the cases have been treated since the disaster. Depression recorded 12.4% prevalence among respondents, mainly among women (85.7%) and individuals in the age group from 40 to 59 years (44%). Eighty percent (80%) of the participants reported to have depression before the disaster and only 20% of them developed it after the accident. With regard to cases that have started before the disaster: 42% remained in the same condition after the disaster and 8% of them got worse. Of the diagnosed cases, 73.3% have been treated since the disaster. Almost 80% of the respondents reported to have been treating their depression.

It was also possible observing positive diagnosis cases: Panic syndrome, 10 cases or 2% of the respondents; Epilepsy, 7 cases; Obsessive-compulsive disorder, 5 cases; Schizophrenia, 4 cases, Alzheimer disease or other dementia types, 2 cases.

Only 13 cases (3.1% of the respondents) presented lesions such as scratches, laceration or wounds, after the accident. There were two bruise and intoxication cases, only one fracture, head trauma and burn case.

The demand for health services remains high, even many months after the disaster. Sixty percent (60%) of the respondents reported to have presented to public health centers; approximately 17% of them looked for health services in other counties, due to many reasons. Ninety-seven percent (97%) of the respondents were assisted in other cities. When they were asked about who afforded or helped paying for the health expenses, 71% of the interviewees said that they were provided by SUS, 14% had health insurance, 11.6% afforded their own treatments and 1.3% had their expenses paid by Samarco. Exams were requested in 48% of the cases, and 84.5% were actually conducted. Residents in rural areas were the ones recording the lowest exam conduction rates, 14.3% of the exams requested for them were not conducted.

Eighty-two point seven percent (82.7%) of the respondents reported to have had their health needs fulfilled. There was broaden health-assistance coverage to the population, including psychiatric and psychological assistance. The evaluation about the access to public health services in Barra Longa after the disaster is very good, mean score 7.2 (0 to 10 scale). It is worth mentioning that Samarco hired health professionals to join the municipal health team, as well as helped building a new Emergency Unit in 2016.

Discussion

It is known that getting sick after the exposure to environmental degradation is an intrinsic response to the degree and time of exposure to the existing risks. The population in Barra Longa was the one, among all cities affected by the disaster, presenting one of the highest exposure-to-mud rates. The released tailing revolved, and increased, the bioavailability in a series of toxic components, including metals. It was evidenced by a series of analysis applied to many natural components: water, soil and fauna (fish and crustaceans) – at levels higher than the ones acceptable for safety according to the Brazilian Legislation, in more than one location at different periods. Barra Longa aerial basin was also intoxicated by dusty from the dry mud, which was released by the city-reconstruction sites. The particulate levels reached high concentration rates, higher than the ones recorded for the big Brazilian metropolises. Besides the aforementioned, part of the population in Volta da Capela had direct contact with the mud that has invaded the city and with the water from the contaminated river. Agriculture is the main economic activity in the district. The county is one of the biggest milk producers in the region and part of its inhabitants has constant contact with crops and cattle breeding. The local population uses to eat locally harvested products.

Maria de Fátima Andrade and her team from the Institute of Astronomy, Geophysics and Atmospheric Sciences of USP assessed the concentration of particulate mater (PM^{10}) – data not published – in two locations in the city: the City Hall and the exposure core (Volta da Capela), in October 2016. Although the data were collected for only one week, results have shown higher values than the ones set for PM_{10} by World Health Organization (WHO) (50 $\mu g/m^3$) (WHO, 2006): daily mean 46 $\mu g/m^3$ and standard deviation – SD 11 $\mu g/m^3$ for the City Hall and mean 58 $\mu g/m^3$ and SD 37 $\mu g/m^3$ for the exposure core.

The adverse effects of atmospheric pollutants are more strongly expressed in individuals with chronic diseases, in children, elderly and, mainly, in less socioeconomically benefited populations – which are characteristic of Volta da Capela.

These data explain the high frequency of acute respiratory diseases in the upper respiratory trait, as well as of skin lesions and ophthalmologic diseases (WHO, 2006). Gelencsér et al. (2011) conducted a study about the analysis applied to red dust from a tailing dam rupture in an aluminum mining company in Hungary. They stated that red mud inhalation did not pose risk to health, since the particles were bigger than 1mm.

Environmental toxic variation can affect health at different severity means and levels. The exposure to heavy metals is concerning and can take to a series of consequences to health, and to neurological, lung, liver, renal and immunological functions, among others.

Studies conducted before the disaster (PIMENTEL et al., 2003; PEREIRA et al., 2008) showed iron, arsenic and manganese in Gualaxo do Norte and Carmo rivers. Most analyses of the water, mud and sediments in the river right after the disaster, and one year after it, were conducted by different organizations (IBAMA, 2015; CPRM, 2015; GOVERNO DO ESTADO DE MINAS GERAIS, 2015; GIAIA, 2016; IGAM, 2016; ANA, 2016; SEGURA, 2016). They observed the presence of metals, such as arsenic, cadmium,

manganese, lead and selenium at levels above the recommended by the Brazilian legislation (BRASIL, 2005; BRASIL, 2011), except for the analysis conducted by Embrapa (2015). The evaluation on the contamination of fish and shrimp species showed high arsenic level in 75% of the assessed samples of pink shrimp and in 100% of *peroá* (*Balistes capriscus)* samples, as well as lead, cadmium, arsenic and manganese contamination levels above the one set by the environmental legislation. These elements are naturally toxic, even at low doses; they can be associated with many adverse effects in the human organism and cause immediate damage to health, as well as have mid- and long-term consequences on it (ICMBio, 2016 a; ICMBio, 2016 b).

Although symptoms reported in the current study can characterize different diseases, they can eventually occur in intoxication cases caused by some metals (IPCS, 1978; WHO, 2015), such as those found in environmental analyses. Acute intoxication with arsenic, for instance, either through inhalation, ingestion or through skin absorption, often expresses itself through respiratory and neurological symptoms. Among many other symptoms, it is also possible observing general malaise, tiredness, headache, anxiety, skin eruptions, itchiness, rash, alopecia, peripheral neuropathy, pain in the extremities, vomiting, diarrhea and cramps. Manganese causes weakness, somnolence, cramps, behavioral changes and brain lesions capable of leading to neural degeneration.

Although we did not point out any symptom suggesting intoxication, results did not allow stating the association between the exposure to metals and getting sick.

The emergence of diseases and symptoms found in Barra Longa also meet the health responses and the time reported by Freitas et al. (2014). It meant an opportunity for local and national health assistance and surveillance systems. Immediate effects, lesions and diseases only happened in 3.1% of the interviewed population. The effects that have emerged from 2 to 6 months after the disaster were the most prevalent, such as respiratory and cutaneous diseases and the Dengue outbreak. A smaller number of disease reports were recorded six months after the disaster, when the interviews were still in process.

The main five reported physical symptoms were headache, cough, leg pain, anxiety and itchiness. Based on the WHO Disease Severity Group, headache and anxiety are among the first ten causes of disabilities (GLOBAL BURDEN OF DISEASES, 2015; LOTUFO, 2016). Headache is the most prevalent neurological condition among the most frequent symptoms in clinical practice. Fifty percent (50%) of the general population has headache for a certain part of the year and more than 90% of it has history of headache throughout life.

Cardiac disease and diabetes diagnoses were recorded for 36.9% of the population. People living in rural areas and in Volta da Capela presented more Hypertension cases (29%) than the ones living in urban areas (24%). Hypertension prevalence in Brazil reaches 20%, on average (PASSOS et al, 2006). There were less diabetes cases in rural areas (1.6%) than in urban areas (6.7%). Volta da Capela had the highest prevalence of it (9.4%). The prevalence of self-referred diabetes in Brazil reaches 6.2% (ISER et al., 2013).

Insomnia prevalence reached 36.9% in all assessed age groups. Estimates show that up to 40% of the Brazilians have suffered, or still suffer, with insomnia in the last twelve months, mainly due to combined factors, including those resulting from physical or mental

disorders, mostly from depression (SOUZA et al., 2004). The city-reconstruction site in Barra Longa, which was even active at night, generated too much noise and it bothered its residents, mainly in the urban area. The noise was reported by 21% of individuals living in urban areas.

Anxiety was reported by 10.6% of the respondents, and 80% of the cases were reported by women. According to WHO, Brazil leads the world ranking of anxiety cases among developing countries: 9.3% of its population (WHO, 2017). Such level is lower than the one recorded in the current study. Depression recorded 12.4% prevalence among respondents, mainly among women – 85.7%. According to WHO, Brazil leads the world ranking on depression prevalence among developing countries: 5.8% of the population; this number is lower than the one recorded in the present study (WHO, 2017).

Finally, the disaster caused by Fundão tailing dam rupture featured an inequity and environmental injustice issue, since part of the most socio-environmentally vulnerable population was the most exposed to the contamination. Therefore, they were more susceptible to the adverse effect from such exposure, besides the negligence and non-operability of different governmental departments and companies due to such events (JACOBI; CIBIM, 2015; WHO, 2006).

It is noticeable that the tragedy subjected the population to a vulnerable physical, socioeconomic and psychological position. This is why individuals living in this site were called "Fundão's disinherited", based on the traditional concept of the term. They can be the only group within a wider category of tragic environmental impacts effecting the economic growth.

Acselrad (2017) analyzes the disaster as an expression of political failure in controlling private interests, as well as discusses the operation of a certain type of "organized class irresponsibility", and the systematic inconsistencies in warnings given by citizens or by groups committed with public interests.

Final considerations

The present study certainly shows that the public health was compromised in many ways. The collected data on health reflected the suffering of the population due to many different complaints, as well as its affected health and quality of life.

The research showed that the assessed population also suffered with the impacts of the disaster and highlighted the need of stopping segregation between the population "directly" affected by the mud (people living close to the riverbed) and the population that was "not affected" by it – these terms were initially used by Samarco to classify the population groups and their rights due to losses. There was no significant difference in the statistical analysis when the groups of diseases between residence locations were compared: close to the river, urban center and rural area. However, the population living in Volta da Capela was more vulnerable to the effects of the disaster and to its consequences. The environmental degradation caused by the contamination with metal in the water, soil and in animals, as well as by the contamination with particulates (at level above that accepted by the legislation),made it possible suggesting risk validation strategies to the systematic

monitoring, and constant elucidation, of relations between intoxication and commitment with population health in the study site. Such strategies are necessary, because this population remains exposed to the contaminant – by contact or inhalation – and presents the previously listed symptoms. It is demanding to map the risk areas and factors that reinforce the vulnerability conditions and the actions taken to overcome them. Such mapping must be turned into a living public-health issue map in the district, as well as compared to the annual health plan and to the governmental planning. It must become the connection capable of assuring the offer of services according to the real local needs. There is the need of observing the environmental equity principles that introduce an ethical component in the management and development of public policies focused on an environmental control consistent with a sustainable development and with social justice.

It is worth reinforcing the local capabilities and the social control, either the planning actions or the responses to the disaster. Emergency or calamities are overcame by the maximum participation of local communities and of populations at risk.

The population must use its legitimate space of right by pinpointing its representations and choices, based on their needs. However, this legitimate space has been supported by local planning conducted by the municipality.

The rehabilitation measures put in practice must be linked to reconstruction strategies in order to turn the disaster into a lesson and into an opportunity to develop and apply some measures aimed at reducing the risk of future disasters and at promoting public health through environmental sustainability and social equity.

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HEALTH EVALUATION OF THE BARRA LONGA POPULATION AFFECTED BY THE DISASTER IN MARIANA COUNTY

***Abstract*:** In 2015, the rupture of Fundão tailing dam caused the largest mining disaster in Brazil. Barra Longa district was the second to bereached by the toxic mudslide. Its population represents one of the most exposed to the risks of environmental degradation. The aim of the present study is to identify the perception of the exposed population about its physical, mental and social health, and about the fulfilment of its needs, based on self-assessment. This is an exploratory, cross-sectional and descriptive study, based on interviews conducted with 507 residents from the urban and rural areas. Thirty-seven percent (37%) of the interviewees reported worse health condition now than before the disaster. Among the spontaneously reported health issues, one finds: respiratory issues (40%), skin conditions (15.8%), behavioral disorders (11%), infectious diseases (6.8%), ophthalmologic issues (6.3%) and digestive problems (3.1%). The five most reported symptoms were headache, cough, leg pain, pruritus and anxiety. The collected data gave voice to multivariate health complaints and to the vulnerability of the local population.

Keywords: Disaster, Man-made Disaster, Health condition, Environmental health, Vulnerability

***Resumo*:** Em 2015 ocorreu o rompimento da barragem do Fundão, causando o maior desastre minerário do Brasil. O município Barra Longa foi o segundo alcançado pela lama tóxica, cuja população representa uma das mais expostas aos riscos da degradação ambiental. O presente estudo tem como objetivo identificar por auto-avaliação, as percepções da população exposta, quanto a sua saúde física, mental e social e ao atendimento das suas necessidades. Trata-se de estudo exploratório, transversal e descritivo, a partir de entrevistas com 507 residentes nas áreas urbana e rural, dos quais 37% referem saúde pior que antes do desastre. Dentre os problemas de saúde relatados espontaneamente, 40% são respiratórios; 15,8%, afecções de pele; 11%, transtornos comportamentais; 6,8%, infecciosos; 6,3%, oftalmológicos; e 3,1%, digestivos. Os cinco sintomas mais relatados são cefaleia, tosse, dor nas pernas, prurido e ansiedade. Os dados dão voz ao sofrimento a multivariadas queixas de saúde e à vulnerabilidade da população.

Palavras-chave: Desastres, Desastres Provocados pelo Homem, Situação de Saúde, Saúde Ambiental, Vulnerabilidade.

Resumen: En 2015 el rompimiento de la presa de residuos de Fundão causó el mayor desastre minero en Brasil. El municipio Barra Longa fue el segundo a ser alcanzado por lodo tóxico, teniendo uno de los mayores riesgos de degradación del medio ambiente. El presente estudio tiene como objetivo identificar las percepciones de la población expuesta, en cuanto a su salud física, mental y social ya la atención de sus necesidades. Se trata de un estudio exploratorio, transversal y descriptivo, a partir de entrevistas con 507 residentes en zonas urbanas y rurales. El 37% informó de peor salud. Principales problemas reportados espontáneamente, 40% son respiratorias; 15,8%, trastornos de la piel; 11%, trastornos de la conducta; 6,8%, infecciosas; 6,3%, oftálmicas; y 3,1%, digestivos. Síntomas más comunes: dolor de cabeza, tos, dolor en las piernas, picazón y ansiedad. Los datos dan voz a las quejas de salud y la vulnerabilidad de la población.

Palabras claves: Desastres, Desastres provocados por el hombre, Situación de salud, Salud ambiental, Vulnerabilidad.