

## ORIGINAL ARTICLE



## Brumadinho Health Project: methodological aspects and epidemiological profile of participants in the cohort baseline

### Projeto Saúde Brumadinho: aspectos metodológicos e perfil epidemiológico dos participantes da linha de base da coorte

Sérgio Viana Peixoto<sup>I,II</sup> , Josélia Oliveira Araújo Firmo<sup>I</sup> , Carmen Ildes Rodrigues Fróes-Asmus<sup>III</sup> , Juliana Vaz de Melo Mambrini<sup>I</sup> , Carlos Machado de Freitas<sup>IV</sup> , Maria Fernanda Lima-Costa<sup>I,V</sup> , Paulo Roberto Borges de Souza Júnior<sup>VI</sup>

<sup>I</sup>Fundação Oswaldo Cruz, René Rachou Institute – Belo Horizonte (MG), Brazil.

<sup>II</sup>Universidade Federal de Minas Gerais, Nursing School – Belo Horizonte (MG), Brazil.

<sup>III</sup>Universidade Federal do Rio de Janeiro, Medical School – Rio de Janeiro (RJ), Brazil.

<sup>IV</sup>Fundação Oswaldo Cruz, National School of Public Health Sérgio Arouca – Rio de Janeiro (RJ), Brazil.

<sup>V</sup>Universidade Federal de Minas Gerais, Medical School – Belo Horizonte (MG), Brazil.

<sup>VI</sup>Fundação Oswaldo Cruz, Institute of Communication and Scientific and Technological Information in Health – Rio de Janeiro (RJ), Brazil.

## ABSTRACT

**Objective:** To present the methodological aspects of the Brumadinho Health Project and to describe the epidemiological profile of participants in the baseline cohort. **Methods:** Prospective, population-based cohort study in a representative sample of residents (aged 12 and over) of Brumadinho, Minas Gerais, after a mining tailings dam failure. Information for the baseline was collected in 2021, two years after the mining tailings dam collapsed, including sociodemographic, health and service use aspects, among others. Prevalence estimates of health outcomes were described in Brumadinho, as well as in the Metropolitan Region of Belo Horizonte and Minas Gerais, using data from the 2019 National Health Survey. All analyses were performed in the software Stata 17.0, considering the sampling weights and design effect. **Results:** 3,080 (86.4%) residents participated in the study, most of them being females (56.7%) and with a mean age of 46.1 years. The diseases more frequently reported were arterial hypertension (30.1%), high cholesterol (23.1%) and depression (22.5%), similarly to what was observed in the Metropolitan Region of Belo Horizonte and Minas Gerais, although the prevalence in Brumadinho was higher. At least one medical appointment and one hospitalization occurred in 75.2% and 9.4% of residents in the past year, respectively. **Conclusion:** It is important to monitor health, physical and mental conditions of residents after the occurrence of a disaster of this magnitude. This information can contribute with risk management of these processes, not only in the affected municipality, but also in other areas where populations are at risk of major disasters.

**Keywords:** Epidemiology of disasters. Cohort studies. Health profile. Health effects of disasters.

**CORRESPONDING AUTHOR:** Sérgio Viana Peixoto. Avenida Augusto de Lima, 1.715, Barro Preto, CEP: 30190-009, Belo Horizonte (MG), Brasil. E-mail: sergio.peixoto@fiocruz.br

**CONFLICT OF INTERESTS:** nothing to declare.

**HOW TO CITE THIS ARTICLE:** Peixoto SV, Firmo JOA, Fróes-Asmus CIR, Mambrini JVM, Freitas CM, Lima-Costa MF, et al. Brumadinho Health Project: methodological aspects and epidemiological profile of participants in the cohort baseline. Rev Bras Epidemiol. 2022; 25:e220002.supl.2. <https://doi.org/10.1590/1980-549720220002.supl.2>

**SCIENTIFIC EDITOR:** Antonio Fernando Boing

**THIS DOCUMENT HAS AN ERRATUM:** <https://doi.org/10.1590/1980-549720220002.supl.2erratum>

This is an open article distributed under the CC-BY 4.0 license, which allows copying and redistribution of the material in any format and for any purpose as long as the original authorship and publication credits are maintained.

Received on: 07/04/2022; Reviewed on: 07/18/2022; Accepted on: 07/18/2022; Corrected on: 09/13/2024.



## INTRODUCTION

There has been an increase worldwide in natural and technological disasters, putting this issue on the agenda of governments and the civil society. In the last 20 years (2000–2019), we have seen a sharp increase in these events, reaching around four billion people and causing the loss of three trillion dollars around the world<sup>1</sup>. A disaster brings with it a rupture in the existing conditions of life and functioning of the affected communities, generating short, medium and long-term impacts for the exposed populations and the health sector. So, generating knowledge that can contribute to reducing the risks of these events is of utmost importance<sup>2,3</sup>.

In general, disasters are associated with mental disorders, increased consumption of alcohol, tobacco and other drugs, increased incidence of cardiovascular and respiratory diseases, and other consequences<sup>3-7</sup>. These effects can occur over many years after an event<sup>8</sup>.

Disasters involving mining tailings dams are of particular interest in Brazil, especially in the state of Minas Gerais (MG)<sup>9</sup>. In 2015, the Fundão mining tailings dam failed in the municipality of Mariana, with important environmental, social, economic impacts and, consequently, effects on the health of the populations<sup>10-13</sup>. More recently, on January 25, 2019, the tailings dam at the mine Córrego do Feijão, under the responsibility of Vale S.A., in Brumadinho (MG), burst, affecting 297.3 acres of land and causing about 270 deaths. The extent of this disaster reflects the relevance of measuring the impacts for the surrounding population, which includes possible environment contamination, unfavorable outcomes on physical and mental health, and economic impacts<sup>14-16</sup>.

From this perspective, producing knowledge about health profile of populations exposed to disasters of this nature and its modification over time, as in prospective studies, can contribute to the planning of preventive, mitigation and adequate response actions aiming at possible new events<sup>8</sup>.

The objective of this study is to depict the methodological aspects of Brumadinho Health Project, a population-based prospective cohort study conducted in the municipality of Brumadinho after the collapse of a mining dam. We also aim to describe the epidemiological profile of the population participating in the baseline cohort, and compare to the same characteristics of the population residing in the metropolitan region of Belo Horizonte (MRBH) and in Minas Gerais.

## METHODS

### Study Design

Brumadinho Health Project is a prospective cohort study coordinated by the Fundação Oswaldo Cruz in Minas Gerais (Fiocruz Minas), in partnership with the Universidade

Federal do Rio de Janeiro (UFRJ) and conducted in the municipality of Brumadinho, Minas Gerais. The main objective of the research is to produce information on health-related conditions of the population residing in the municipality after the Brumadinho disaster and in subsequent years. More details are available on the project's website (<http://www.minas.fiocruz.br/saudebrumadinho/>). Baseline information was collected between June and November 2021, and three more annual collections will be carried out to build a long-term follow-up of this population.

The Brumadinho Health Project was approved by the Research Ethics Committee of Fiocruz Minas (20814719.5.0000.5091), and all participants signed an Informed Consent Form and/or an Informed Consent Term for the underage, accompanied by the informed consent form by caregivers.

### Area

The municipality of Brumadinho is located in the Metropolitan Region of Belo Horizonte (MRBH). It extends over an area of 639.4 km<sup>2</sup>, with an estimated population of 41,208 residents in 2021. In 2010, the municipal human development index (HDI) was 0.747, and infant mortality rate was 13.67 deaths per 1,000 live births in 2020<sup>17</sup>.

Data from May 2022 show that the municipality has 15 basic health units, two psychosocial care centers, one general hospital and one polyclinic<sup>18</sup>, with 100% coverage of the family health strategy (FHS)<sup>19</sup>.

The main economic activity in the municipality is mining, especially conducted by Vale S.A. However, agriculture is also an activity that generates employment and income, with special emphasis on the production of fruit and vegetables, mainly by small properties and family farming. Finally, the tourist potential of the municipality stands out, with a recent increase in the number of hotel beds and acting of hundreds of entrepreneurs<sup>20</sup>.

The path of the tailings mud from the dam failure can be seen in Figure 1. The location of the municipality in the state of MG and in Brazil is shown in Figure 2.

### Target Population and Sample

Considering that the disaster in the municipality caused different types and degrees of exposure, there was no differentiation between the affected and non-affected population to estimate the sample size.

The sampling plan was then designed to represent the population aged 12 years or older residing in the municipality. The aim was to obtain information on three estimation domains:

1. The domain of people directly exposed to the failure of the tailings dam at Córrego do Feijão mine, including communities closest to the affected area;
2. The domain of people who resided in an area with mining activity; and
3. The domain of people not directly exposed to tailings mud or mining activity.

This planning then considered the stratification of the population by census sector, through the use of cartography from the Brazilian Institute of Geography and Statistics

(IBGE) in 2019, in a way that the aggregation of sectors allowed the construction of the aforementioned estimation domains. All households in regions considered exposed to

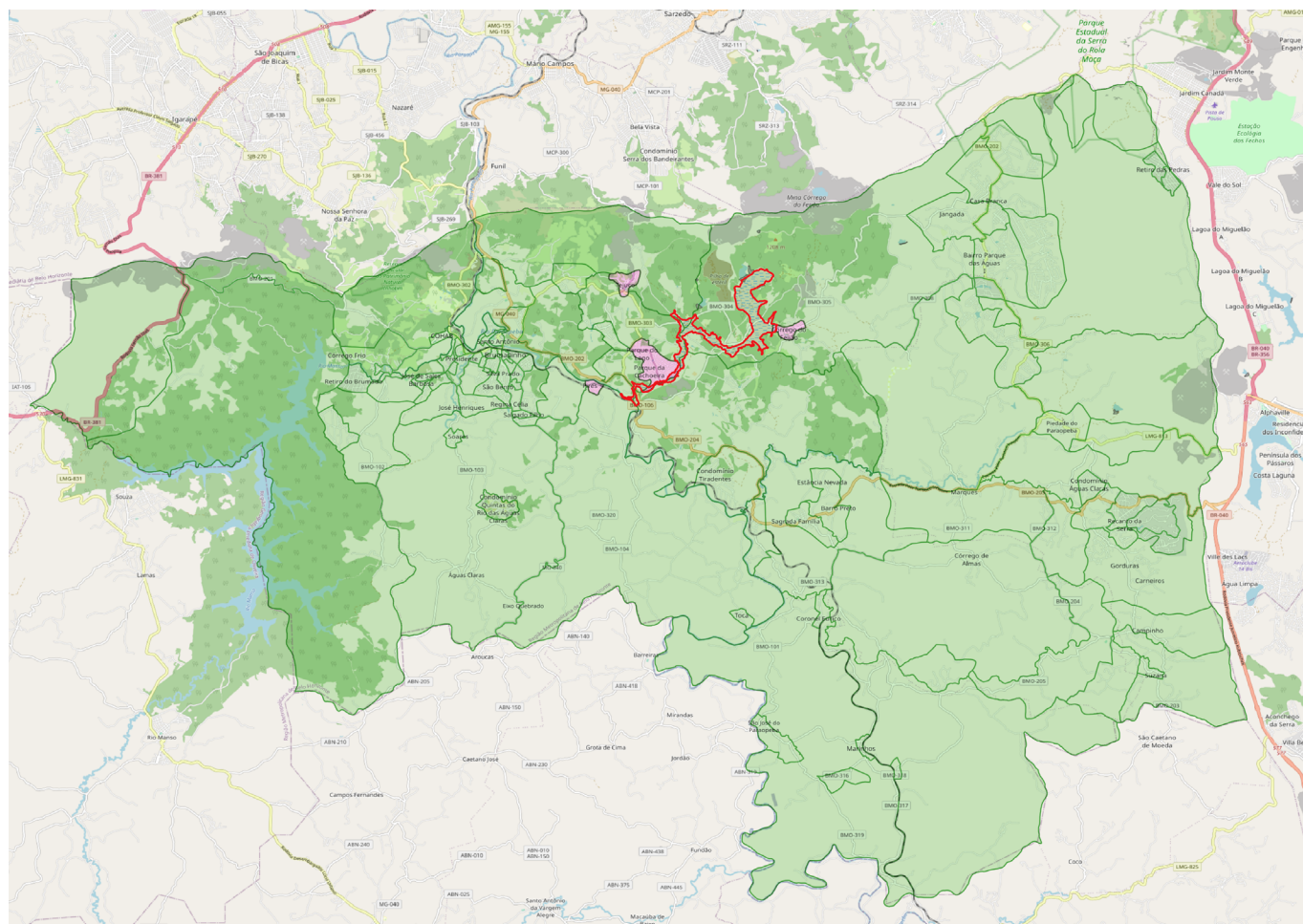


Figure 1. Municipality of Brumadinho (MG), with limits of census sectors and mud path (in red).

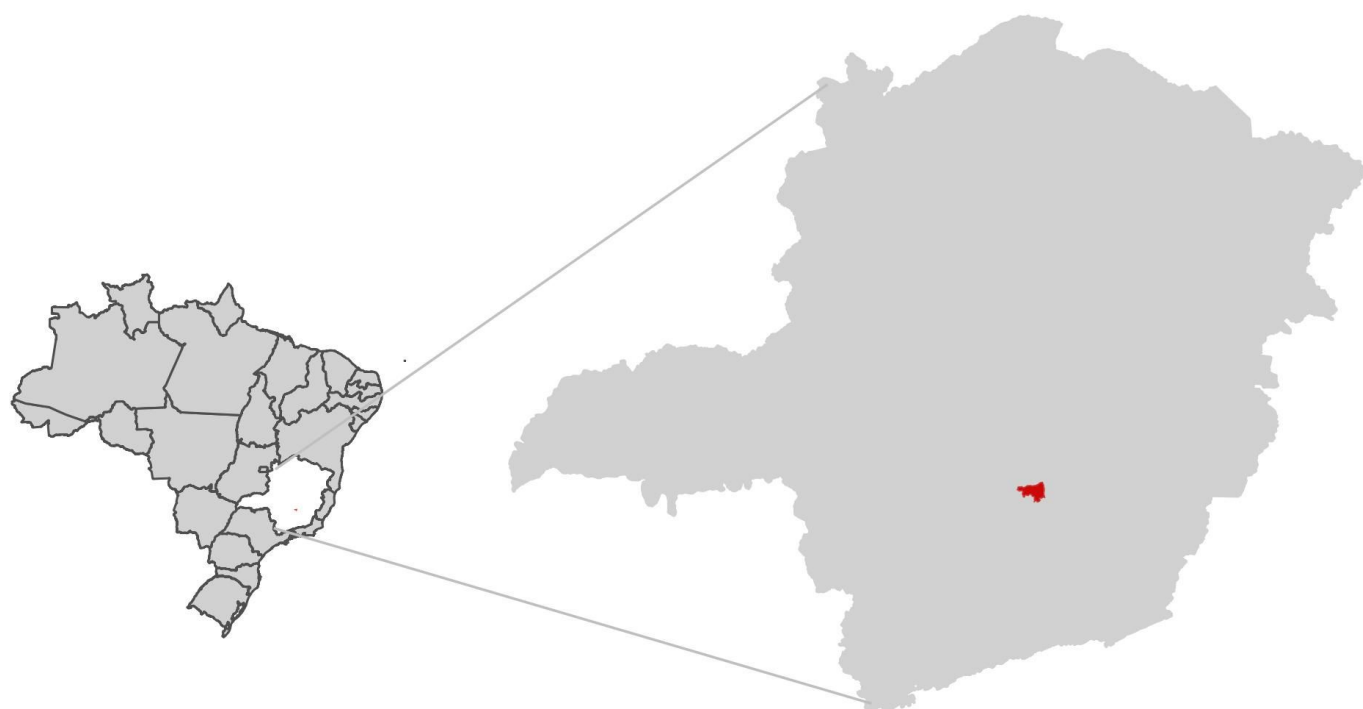


Figure 2. Location of the municipality of Brumadinho (in red) in the state of Minas Gerais and Brazil.

the disaster or mining activity were included, in addition to a random sample of households in the domain considered not directly exposed. Additionally, residents of the *Córrego do Feijão* region (where the dam was located) at the time of the disaster and who no longer lives there were included, since many properties were destroyed, sold or abandoned.

The balance between exposed and non-exposed domains was considered for the sizing of the sample. Thus, the sample size of the unexposed area was calculated specifying a minimum proportion equal to 3%, with a relative error margin of the estimate of up to 45% and a 95% confidence interval. A sampling design effect (DEFF) of 1.1 was also considered. This estimate led to the random selection of seven households by simple inverse sampling<sup>21</sup>, considered primary sampling units (PSU), in each census tracts, covering the rest of the municipality.

In all domains, all residents of each selected household were enrolled and those aged 12 years or older, who consented to participate in the research, were interviewed. Before data collection, the project was widely discussed by health professionals, community leaders and social movements in order to clarify all procedures.

Table 1 describes some information according to the strata that made up the sample. A total of 1,446 households were visited, and 3,563 people aged 12 years and over were invited to participate in the survey, with an acceptance rate of 86.4%.

As the research sample was stratified, sample weights were estimated for each household<sup>22</sup>, to compensate for non-response effects and produce estimates with a lower margin of error. Based on this first estimate, calibrated weights of participating households and individuals were generated using the population projection for 09/01/2021, by the linear trend method used by IBGE in population projections<sup>23</sup>. To estimate variances, a combination of primary cluster and linearization methods should be used<sup>24</sup>.

### Baseline Information and Collection Instruments

Project baseline information was obtained through interviews and collection of biological material.

The interview was carried out in selected households, with all residents in the age group of interest contemplating three questionnaires: household and individual,

**Table 1. Permanent private households selected, eligible people (12 years and over) and interviewed participants, according to geographic stratum, in Brumadinho (MG). Brumadinho Health Project, 2021.**

Geographical stratum	Permanent private households	People		
		Eligible	Interviewees	%
Not exposed	763	1,859	1,562	84.0
Directly exposed	438	1,061	981	92.5
Mining region	245	643	537	83.5
Total	1,446	3,563	3,080	86.4

adolescents and adults. The household questionnaire was answered by any adult able to provide the requested information:

- demographic characteristics of all residents;
- physical characteristics of the household, including source of water and sanitation;
- movable and immovable property and domestic workers;
- income and benefits;
- food growing and animal husbandry;
- scale of food and nutrition insecurity.

The questionnaire for adolescents (12 to 17 years old) included:

- sociodemographic features;
- enrollment and attendance at school;
- information about contact with river water and tailings mud;
- physical activity, tobacco use, alcohol consumption, and food consumption indicators;
- general health conditions (self-rated health, medical diagnosis of diseases, signs and symptoms);
- mental health;
- non-pharmacological measures against COVID-19;
- use of health services (frequency of use and reference service); and
- body image.

For the population aged 18 and over, the questionnaire included:

- sociodemographic information;
- information about contact with river water and tailings mud;
- social capital, neighborhood perception and discrimination;
- job characteristics (current and past);
- physical activity, tobacco use, alcohol consumption, and food consumption indicators;
- general health conditions (self-rated health, medical diagnosis of diseases, signs and symptoms);
- use of medication for certain conditions;
- mental health;
- non-pharmacological measures against COVID-19;
- use of health services (frequency of use, reference service, evaluation of service used, preventive exams, and vaccines); and
- loss of friends and family in the disaster.

Biological material (blood and urine) was collected from 2,782 (90.3% of respondents) participants, and the entire process was carried out by a hired laboratory. Based on the blood matrix, the following tests were performed: complete blood count, total cholesterol and fractions, triglycerides, glycated hemoglobin, liver (TGO and TGP) and kidney (creatinine and urea) function, high sensitivity C-reactive pro-



tein, SARS-CoV-2 antibodies, manganese and lead metals. In urine, the metals arsenic, cadmium and mercury were evaluated. The results of these exams will be presented in other publications.

### Follow-ups

The population participating in the baseline cohort will be followed up annually, which will allow a longitudinal assessment of relevant aspects after the disaster. The follow-ups will initially take place between 2022 and 2024<sup>25</sup>, but this cohort is expected to last longer, providing medium and long-term evidence on the health conditions of the residents.

Physical measurements (blood pressure and anthropometry) will be performed in 2022 and 2024, combined with laboratory tests (2021 and 2023). These measurements will be obtained at the participant's household after the interviews and using standardized procedures.

### Data Collection and Quality Control Procedures

The information collected in the study was discussed in a workshop with specialists in topics related to the effects of disasters. The creation of the questionnaires was based on national research<sup>26,27</sup> and on evidence already produced on the effects of disasters on the health of populations<sup>4,7,13</sup>. Regarding mental health outcomes, instruments that could be applied to different age groups and that had been validated for Brazil were considered: post-traumatic stress disorder ("Post-Traumatic Stress Disorder Checklist – Civilian Version")<sup>28</sup>, depression ("Patient Health Questionnaire-9")<sup>29</sup>, anxiety disorder ("General Anxiety Disorder")<sup>30</sup> and resilience assessment ("Resilience Scale")<sup>31</sup>.

The baseline questionnaires were administered by trained interviewers using electronic devices, at the participant's home, by a hired company with extensive experience in epidemiological research. The households were visited up to three times, on different days and times, in order to ensure that all eligible residents were interviewed. The portion of the questionnaire referring to household was answered by an adult resident, and individual interviews were carried out with the resident himself or with the help of a close respondent, in case the participant had difficulties answering it (occurred in 9.1% of the interviews).

During data collection, some techniques were used for quality control. Reports were analyzed with eyes to duration of interviews, number of visits recorded in each household and geographic location at the time of interview. If any possible inconsistency was detected, the field supervisor would double check it; the supervisor's visit would confirm information, by reopening the interview and correcting what was necessary.

After training, a pilot study was conducted in a community that had suffered a natural disaster to assess the relevance of the questionnaire, of the training and of the proposed logistics for the fieldwork. This study was carried out in two census sectors, with ten complete interviews each.

Biological material (blood and urine) was collected by a hired laboratory reference for field studies and quality certification. Samples were collected at the participant's households after the interviews, which had been pre-scheduled. Blood collection was performed by trained technicians, no need for fasting, and urine samples were collected after delivery of container and instructions for collection.

These samples were sent to a processing center in the municipality of Brumadinho, for preparation and shipment to the main laboratory. This entire process was carried out in compliance with defined guidelines for the transportation and packaging of samples, including strict temperature control. There was then processing, performance of defined dosages and storage of serum, plasma, leukocyte supernatant and urine for the construction of a biorepository and possibility of future evaluations.

All the information generated by the interviews and laboratory tests formed a single database, which was subjected to a careful consistency analysis based on simple frequency distributions of all variables and compatibility between responses to different items, which indicated the collection process and database adequacy.

### Statistical Analysis

For the present article, the prevalence and respective confidence intervals (95%CI) of some sociodemographic characteristics, health conditions and use of health services by adolescents (12 to 17 years old) and/or adults (18 years old or older) participating in the baseline project were described, along with mean values and confidence intervals for the age of this population.

For the purpose of comparison and contextualization of characteristics, the same information was presented in regard to the state of Minas Gerais and for the MRBH, of which Brumadinho is a part, using data from the National Health Survey (PNS), 2019. The PNS allows to disaggregate information and split it for the state and the metropolitan region<sup>27</sup>. This analysis included 7,107 residents of the MRBH and 14,831 residents of Minas Gerais aged 12 years or older.

All analyses were carried out in the software Stata 17.0 (StataCorp LLC, CollegeStation, TX), considering the sample weights and the sample design effect of both surveys, using command "svy" of Stata.

## RESULTS

Among the 3,080 participants, 56.7% were females and 42.2% self-declared as white-skinned. The mean age was 46.1 years (95%CI 44.9–47.4), and 35.2% of them had a private health insurance plan. Among adults, most were married (60.0%), and 37.1% had not completed the elementary school; Paid work in the last 30 days was reported by 48.5% of adults (Table 2).

Table 3 shows some variables related to the health conditions of the project participants and for both the MRBH and Minas Gerais. Health was self-rated as good/very good by 80.3% of adolescents and 62.3% of adults, values slightly lower than those observed in the two other locations. Among diseases with a previous medical diagnosis, the most common in Brumadinho were arterial hypertension (30.1%), high cholesterol (23.1%) and depression (22.5%), similar to what was observed in the MRBH and Minas Gerais.

Regarding the use of health services, 40.3% of adults in Brumadinho reported having had three or more medical appointments in the past year, and 9.4% had been hospitalized in the same period (Table 4).

## DISCUSSION

In general, the sociodemographic characteristics are similar to those observed in the MRBH and/or Minas Gerais. The proportional distribution in the assessment of health condi-

**Table 2. Sociodemographic characteristics, work and health insurance of the population aged 12 years and over, according to place of residence. Brumadinho Health Project, 2021.**

Variables	% or mean (95%CI)		
	Brumadinho	MRBH	Minas Gerais
Women	56.7 (54.4–58.9)	53.6 (52.6–54.7)	52.5 (51.6–53.4)
Age, mean (95%CI)	46.1 (44.9–47.4)	41.6 (40.8–42.3)	42.9 (42.3–43.6)
Ethnicity/skin color			
White	42.2 (38.8–45.7)	34.4 (31.6–37.4)	41.8 (39.4–44.2)
Black	12.0 (10.1–14.2)	16.6 (14.5–18.9)	13.7 (12.3–15.3)
Brown	44.8 (41.5–48.1)	48.2 (45.4–51.0)	43.9 (41.9–46.0)
Other	1.0 (0.6–1.8)	0.8 (0.4–1.4)	0.6 (0.4–0.9)
Marital status*			
Single	26.3 (23.7–29.0)	45.4 (43.7–47.1)	40.2 (38.7–41.7)
Married	60.0 (56.4–62.8)	41.2 (39.4–43.0)	44.2 (42.6–45.9)
Separated	7.8 (6.3–9.7)	7.7 (6.8–8.6)	8.3 (7.5–9.2)
Widow(er)	6.3 (5.1–7.6)	5.8 (5.1–6.5)	7.3 (6.6–8.2)
Education*			
Incomplete elementary school	37.1 (34.4–39.9)	25.5 (23.1–27.9)	37.4 (35.4–39.5)
Complete primary education	16.3 (14.4–18.5)	16.5 (15.3–17.9)	14.7 (13.6–15.9)
Complete high school	29.0 (26.2–32.1)	38.9 (37.2–40.7)	33.8 (32.3–35.3)
Complete higher education	17.6 (15.0–20.4)	19.1 (16.8–21.6)	14.1 (12.6–15.8)
Employed (paid work)*, †	48.5 (45.2–51.7)	59.7 (57.6–61.8)	55.7 (54.0–57.3)
Has a health insurance plan	35.2 (32.1–38.5)	38.8 (35.7–42.0)	28.6 (26.0–31.3)

95%CI: confidence intervals (95%); MRBH: metropolitan region of Belo Horizonte; \*participants aged 18 or over; †In the National Health Survey (MRBH and MG) the question is based “on the reference week”, and not on the last 30 days, as considered in the Brumadinho Health Project.

**Table 3. Self-rated health and selected health conditions, according to age group and place of residence. Brumadinho Health Project, 2021.**

Variables	% (95%CI)		
	Brumadinho	MRBH	Minas Gerais
Adolescents (12 to 17 years old)			
Good/very good self-rated health	80.3 (70.3–87.5)	95.1 (92.4–96.8)	89.7 (86.6–92.1)
Adults (18 years and over)			
Good/very good self-rated health	62.3 (59.3–65.2)	78.9 (77.2–80.5)	70.8 (69.3–72.3)
Hypertension	30.1 (27.3–33.0)	23.4 (21.5–25.5)	28.0 (26.1–30.0)
Diabetes	9.8 (8.3–11.6)	8.1 (6.9–9.5)	8.3 (7.3–9.4)
High cholesterol	23.1 (20.6–25.7)	15.5 (13.4–17.9)	16.4 (14.8–18.1)
Heart disease*	6.2 (4.8–8.1)	5.1 (4.2–6.3)	6.2 (5.4–7.2)
Stroke	2.2 (1.5–3.3)	1.2 (0.9–1.8)	1.9 (1.5–2.5)
Chronic kidney failure	2.8 (2.0–3.8)	1.4 (0.8–2.2)	1.7 (1.2–2.2)
Chronic back problem†	21.1 (18.4–24.1)	13.2 (11.2–15.5)	22.0 (20.1–24.0)
Cancer	3.7 (2.7–5.0)	2.4 (1.9–3.2)	2.4 (2.0–3.0)
Asthma or asthmatic bronchitis	7.3 (5.9–8.9)	6.8 (5.6–8.3)	6.0 (5.1–7.1)
Emphysema or chronic bronchitis or COPD	3.5 (2.5–4.9)	1.6 (1.0–2.4)	1.7 (1.2–2.3)
Arthritis or rheumatism	6.9 (5.4–8.9)	5.2 (4.3–6.3)	8.8 (7.6–10.1)
Depression	22.5 (20.0–25.5)	14.1 (12.4–16.0)	13.7 (12.2–15.3)

95%CI: confidence intervals (95%); MRBH: metropolitan region of Belo Horizonte; with the exception of self-rated health, all diseases listed in the table were mentioned, considering previous medical diagnosis (ever in life); COPD: chronic obstructive pulmonary disease; \*angina, heart attack or heart failure; †National Health Survey (MRBH and MG) based on the interviewee's report and not on previous medical diagnosis.

**Table 4. Use of health services among adults, by place of residence. Brumadinho Health Project, 2021.**

Variables	% (95%CI)		
	Brumadinho	MRBH	Minas Gerais
Number of medical appointments in the last 12 months			
None	24.8 (22.4–27.4)	20.8 (19.1–22.7)	21.8 (20.5–23.1)
One	16.9 (14.2–20.0)	19.5 (18.1–21.1)	22.6 (21.3–23.9)
Two	18.0 (15.6–20.7)	17.9 (16.7–19.2)	17.3 (16.4–18.3)
Three or more	40.3 (37.0–43.7)	41.8 (39.8–43.7)	38.3 (36.6–40.0)
Hospitalization in the last 12 months	9.4 (7.6–11.6)	7.2 (6.4–8.1)	7.4 (6.8–8.1)

95%CI: confidence intervals (95%); MRBH: metropolitan region of Belo Horizonte.

tions shows a slightly higher prevalence than the reported in the other two regions, with emphasis on the higher rates of high cholesterol (23.1%) and depression (22.5%) among adults of Brumadinho. The use of health services was also similar to that observed in the MRBH and Minas Gerais.

The proportion of adults in Brumadinho who self-rated their health as good or very good was similar to what was observed in the Brazilian population in 2019 (66.1%)<sup>32</sup>, although it can be slightly inferior to what was observed in the MRBH (78.9%) and in Minas Gerais (70.8%). The relevance of this variable relates to the fact that it is a multidimensional measure that considers objective and subjective aspects, being associated with several health outcomes and with important social determination<sup>33–36</sup>.

Regarding previous medical diagnoses for the conditions investigated, the prevalence was relatively higher than that reported in the MRBH and Minas Gerais. This higher prevalence may be related to the disaster, considering that some studies show a greater burden of disease after a major event<sup>3,4,6,7,37–39</sup>, but one should also consider the universal coverage of the FHS in the municipality<sup>19</sup>, which can increase access to services and medical diagnosis<sup>40,41</sup>, especially if the population started to seek this service more after the event.

Attention is drawn to the significant burden of cardiovascular risk factors (hypertension, diabetes and high cholesterol), the report of respiratory diseases, which may be related to environmental dust, and the high prevalence of depression (22.5%), elements that require special attention from the health service. In Brumadinho, soon after the dam failure, psychiatric disorders were very common<sup>42</sup>, similarly to what was observed in some groups affected by the dam failure in Mariana<sup>43</sup>. These results are consistent with the high impact of natural or technological disasters on the mental health of populations experiencing them<sup>38,44</sup>, which, in the case of Brumadinho, may have worsened with the COVID-19 pandemic, which also had a negative influence on mental health of populations<sup>45</sup>.

Another relevant aspect is the exposure to metals of interest to public health, due to important environmental impact. Previous studies have indicated the presence of metals in the tailings mud, water and sediments of the Paraopeba River, which demonstrates a potential impact on the health of residents<sup>14,25,46,47</sup>. This aspect, along with

others of greater relevance such as mental health and respiratory diseases, will be addressed in more detail in other publications.

The Brumadinho Health Project has some limitations. As the baseline was established after the tailings dam collapsed, there are difficulties in establishing a direct relationship between the analyzed outcomes and the disaster. In addition, as with any cohort study, there is a possibility of loss to follow-up, which is intended to be avoided by raising the population's awareness of the importance of the study and collecting detailed information to enable the localization of participants in the event of a change of address. Finally, data collection for the baseline took place two years after the dam failure, given the impossibility of carrying out fieldwork at the beginning of the COVID-19 pandemic. This distance from the date of event may have hampered the reporting of information related to the disaster itself, in addition to influencing some results, especially mental health outcomes, as mentioned earlier.

On the other hand, a prospective population-based study presents a lower possibility of occurrence of memory and selection bias, considering the understanding of the temporal relationship between the variables and the use of a probabilistic sample of the entire municipality. This design will make it possible to assess the consequences of some relevant exposures on health conditions, health behaviors and use of services over time, constituting an innovative investigation into the processes of illness after a major disaster. This knowledge can contribute to the risk management of such processes not only in the affected municipality, but in areas where populations are at similar risk.

The importance of monitoring the health, physical and mental conditions after the occurrence of events like this in the medium and long term is evident<sup>3,14</sup>. The knowledge produced by this study must be articulated with other initiatives, so that it contributes to the multidimensional understanding of the disaster of Brumadinho, considering the complex nature of these events<sup>14</sup>, and to meeting the priorities of the Sendai Framework for Reduction of Disaster Risks – 2015–2030<sup>14,48</sup>. Finally, it is important to mention the need for coordinated actions by various spheres of the Unified Health System (SUS) and intersectoral actions to adequately serve populations exposed to the risk of disasters, increasing the success of health recovery actions and

environmental damage, in line with several Sustainable Development Goals, contributing to the achievement of the 2030 Agenda<sup>49,50</sup>.

## REFERENCES

- Centre for Research on the Epidemiology of Disasters. United Nations Office for Disaster Risk Reduction. The human cost of disasters: an overview of the last 20 years (2000-2019) [Internet]. 2020 [cited on Jun 26, 2022]. Available at: <https://www.undrr.org/publication/human-cost-disasters-overview-last-20-years-2000-2019>
- Freitas CM, Mazoto ML, Rocha V, orgs. Guia de preparação e respostas do setor saúde aos desastres. Rio de Janeiro: Secretaria de Vigilância em Saúde; 2018.
- Lucchini RG, Hashim D, Acquilla S, Basanets A, Bertazzi PA, Bushmanov A, et al. A comparative assessment of major international disasters: the need for exposure assessment, systematic emergency preparedness, and lifetime health care. *BMC Public Health* 2017; 17 (1): 46. <https://doi.org/10.1186/s12889-016-3939-3>
- Geng F, Zhou Y, Liang Y, Fan F. A longitudinal study of recurrent experience of earthquake and mental health problems among Chinese adolescents. *Front Psychol* 2018; 9: 1259. <https://doi.org/10.3389/fpsyg.2018.01259>
- Vlahov D, Galea S, Ahern J, Resnick H, Boscarino JA, Gold J, et al. Consumption of cigarettes, alcohol, and marijuana among New York City residents six months after the September 11 terrorist attacks. *Am J Drug Alcohol Abuse* 2004; 30 (2): 385-407. <https://doi.org/10.1081/ada-120037384>
- Brackbill RM, Cone JE, Farfel MR, Stellman SD. Chronic physical health consequences of being injured during the terrorist attacks on World Trade Center on September 11, 2001. *Am J Epidemiol* 2014; 179 (9): 1076-85. <http://doi.org/10.1093/aje/kwu022>
- Hikichi H, Aida J, Kondo K, Tsuboya T, Kawachi I. Residential relocation and obesity after a natural disaster: a natural experiment from the 2011 Japan Earthquake and Tsunami. *Sci Rep* 2019; 9 (1): 374. <https://doi.org/10.1038/s41598-018-36906-y>
- Freitas CM, Silva DRX, Sena ARM, Silva EL, Sales LBF, Carvalho ML, et al. Desastres naturais e saúde: uma análise da situação do Brasil. *Ciênc Saúde Coletiva* 2014; 19 (9): 3645-56. <https://doi.org/10.1590/1413-81232014199.00732014>
- Pinto-Coelho RM, Vieira EM, Pio FPB, Almeida VF, Santos RE. Atlas das barragens de mineração em Minas Gerais. *Caderno de Geografia* 2021; 31 (1): 208-59. <https://doi.org/10.5752/P.2318-2962.2021v31nesp1p260>
- Carvalho MS, Moreira RM, Ribeiro KD, Almeida AM. Concentração de metais no rio Doce em Mariana, Minas Gerais, Brasil. *Acta Brasiliensis* 2017; 1 (3): 37-41. <https://doi.org/10.22571/Actabra13201758>
- Freitas CM, Silva MA, Menezes FC. O desastre na barragem de mineração da Samarco: fratura exposta dos limites do Brasil na redução de risco de desastres. *Cienc Cult* 2016; 68 (3): 25-30. <http://dx.doi.org/10.21800/2317-66602016000300010>
- Ramos AA, Oliveira JF, Nardi MF, Cunha MA. O caso de estudo "Samarco": os impactos ambientais, econômicos e sociais, relativos ao desastre de Mariana. *Unisantia BioScience* 2017; 6 (4): 316-27.
- Vormittag EMPAA, Oliveira MA, Gleriano JS. Avaliação de saúde da população de Barra Longa afetada pelo desastre de Mariana, Brasil. *Ambient Sociedade* 2018; 21: e01222. <https://doi.org/10.1590/1809-4422asoc0122r2vu18L1AO>
- Freitas CM, Barcellos C, Asmus CIRF, Silva MA, Xavier DR. Da Samarco em Mariana à Vale em Brumadinho: desastres em barragens de mineração e Saúde Coletiva. *Cad Saúde Pública* 2019; 35 (5): e00052519. <https://doi.org/10.1590/0102-311X00052519>
- Freitas CM, Barcellos C, Heller L, Luz ZMP. Desastres em barragens de mineração: lições do passado para reduzir riscos atuais e futuros. *Epidemiol Serv Saúde* 2019; 28 (1): e20180120. <https://doi.org/10.5123/S1679-49742019000100020>
- Pereira LF, Cruz GB, Guimarães RMF. Impactos do rompimento da barragem de rejeitos de Brumadinho, Brasil: uma análise baseada nas mudanças de cobertura da terra. *J Env Anal Progr* 2019; 4 (2): 122-9. <https://doi.org/10.24221/jeap.4.2.2019.2373.122-129>
- Brasil. Instituto Brasileiro de Geografia e Estatística. Conheça cidades e estados do Brasil [Internet]. 2022 [cited on Jun 14, 2022]. Available at: <https://cidades.ibge.gov.br/>
- Brasil. Ministério da Saúde. Cadastro Nacional dos Estabelecimentos de Saúde do Brasil – CNES [Internet]. 2022 [cited on Jun 19, 2022]. Available at: <https://datasus.saude.gov.br/cnes-estabelecimentos>
- Brasil. Ministério da Saúde. Secretaria de Atenção Primária à Saúde. E-Gestor Atenção Básica: Informação e Gestão da Atenção Básica [Internet]. 2022 [cited on Jun 19, 2022]. Available at <https://egestorab.saude.gov.br/>
- Prefeitura Municipal de Brumadinho. Dossiê Brumadinho [Internet]. 2021 [cited on Jul 18, 2019]. Available at: <https://brumadinho.mg.gov.br/publicacoes/0/1>
- Vasconcellos MTL, Silva PLN, Szwarcwald CL. Sampling design for the World Health Survey in Brazil. *Cad Saude Publica* 2005; 21 Suppl 1: S89-S99. <https://doi.org/10.1590/s0102-311x2005000700010>
- Valliant R, Dever JA. Survey Weights: a step-by-step guide to calculation. Texas: Stata Press; 2018.
- Brasil. Instituto Brasileiro de Geografia e Estatística. Estimativas da população residente para os municípios e para as unidades da federação brasileiros com data de referência em 1º de julho de 2019. Rio de Janeiro: IBGE; 2019.
- Pessoa DG, Silva PN. Análise de dados amostrais complexos. São Paulo: Associação Brasileira de Estatística; 1998.
- Brasil. Ministério da Saúde. Secretaria de Vigilância em Saúde. Um ano do desastre da Vale: organização e resposta do Ministério da Saúde. *Boletim Epidemiológico*, Ministério da Saúde; 2020.



26. Lima-Costa MF, Andrade FB, Souza Jr PRB, Neri AL, Duarte YAO, Castro-Costa E, et al. The Brazilian Longitudinal Study of Aging (ELSI-Brazil): objectives and design. *Am J Epidemiol* 2018; 187 (7): 1345-53. <https://doi.org/10.1093/aje/kwx387>
27. Stopa SR, Szwarcwald CL, Oliveira MM, Gouvea ECDP, Vieira MLFP, Freitas MPS, et al. Pesquisa Nacional de Saúde 2019: histórico, métodos e perspectivas. *Epidemiol Serv Saúde* 2020; 29 (5): e2020315. <https://doi.org/10.1590/s1679-49742020000500004>
28. Berger W, Mendlowicz MV, Souza WF, Figueira I. Equivalência semântica da versão em português da Post-Traumatic Stress Disorder Checklist - Civilian Version (PCL-C) para rastreamento do transtorno de estresse pós-traumático. *R Psiquiatr* 2004; 26 (2): 167-75. <https://doi.org/10.1590/S0101-81082004000200006>
29. Munhoz TN, Santos IS, Matijasevich A. Depression among Brazilian adolescents: a cross-sectional population-based study. *J Affect Disord* 2015; 175: 281-6. <http://doi.org/10.1016/j.jad.2015.01.031>
30. Mossman SA, Luft MJ, Schroeder HK, Varney ST, Fleck DE, Barzman DH, et al. The generalized anxiety disorder 7-item scale in adolescents with generalized anxiety disorder: signal detection and validation. *Ann Clin Psychiatry* 2017; 29 (4): 227-34A. PMID: 29069107
31. Pesce RP, Assis SG, Avanci JQ, Santos NC, Malaquias JV, Carvalhaes R. Adaptação transcultural, confiabilidade e validade da escala de resiliência. *Cad Saúde Pública* 2005; 21 (2): 436-48. <https://doi.org/10.1590/S0102-311X2005000200010>
32. Brasil. Instituto Brasileiro de Geografia e Estatística. Pesquisa nacional de saúde 2019: percepção do estado de saúde, estilos de vida, doenças crônicas e saúde bucal: Brasil e grandes regiões. Rio de Janeiro: IBGE; 2020.
33. Sousa JL, Alencar GP, Antunes JLF, Silva ZP. Marcadores de desigualdade na autoavaliação da saúde de adultos no Brasil, segundo o sexo. *Cad Saúde Pública* 2020; 36 (5): e00230318. <https://doi.org/10.1590/0102-311X00230318>
34. Răileanu Szeles M. Comparative examination of self-perceived health and other measures of the quality of life across the EU-27. *Soc Indic Res* 2018; 137: 391-411. <https://doi.org/10.1007/s11205-017-1597-1>
35. Roelen CAM, Heymans MW, Twisk JWR, Laaksonen M, Pallesen S, Magerøy N, et al. Health measures in prediction models for high sickness absence: single-item self-rated health versus multi-item SF-12. *Eur J Public Health* 2015; 25 (4): 668-72. <https://doi.org/10.1093/eurpub/cku192>
36. Cislighi B, Cislighi C. Self-rated health as a valid indicator for health-equity analyses: evidence from the Italian health interview survey. *BMC Public Health* 2019; 19 (1): 533. <https://doi.org/10.1186/s12889-019-6839-5>
37. Ngaruiya C, Bernstein R, Leff R, Wallace L, Agrawal P, Selvam A, et al. Systematic review on chronic non-communicable disease in disaster settings. *BMC Public Health* 2022; 22 (1): 1234. <http://doi.org/10.1186/s12889-022-13399-z>
38. Jordan HT, Osahan S, Li J, Stein CR, Friedman SM, Brackbill RM, et al. Persistent mental and physical health impact of exposure to the September 11, 2001 World Trade Center terrorist attacks. *Environ Health* 2019; 18 (1): 12. <https://doi.org/10.1186/s12940-019-0449-7>
39. Gallardo AR, Pacelli B, Alesina M, Serrone D, Iacutone G, Faggiano F, et al. Medium- and long-term health effects of earthquakes in high-income countries: a systematic review and meta-analysis. *Int J Epidemiol* 2018; 47 (4): 1317-32. <https://doi.org/10.1093/ije/dyy130>
40. Pinheiro PC, Barros MBA, Szwarcwald CL, Machado ÍE, Malta DC. Diferenças entre medidas autorreferidas e laboratoriais de diabetes, doença renal crônica e hipercolesterolemia. *Ciênc Saúde Coletiva* 2021; 26 (4): 1207-9. <https://doi.org/10.1590/1413-81232021264.44582020>
41. Vellakkal S, Subramanian SV, Millett C, Basu S, Stuckler D, Ebrahim S. Socioeconomic inequalities in non-communicable diseases prevalence in India: disparities between self-reported diagnoses and standardized measures. *PLoS One* 2013; 8 (7): e68219. <https://doi.org/10.1371/journal.pone.0068219>
42. Noal DS, Rabelo IVM, Chachamovich E. O impacto na saúde mental dos afetados após o rompimento da barragem da Vale. *Cad Saúde Pública* 2019; 35 (5): e00048419. <http://doi.org/10.1590/0102-311X00048419>
43. Neves MCL, Roque M, Freitas AA, Garcia F, orgs. PRISMMA: pesquisa sobre a saúde mental das famílias atingidas pelo rompimento da barragem de Fundão em Mariana. Belo Horizonte: Corpus; 2018.
44. Yokoyama Y, Otsuka K, Kawakami N, Kobayashi S, Ogawa A, Tannno K, et al. Mental health and related factors after the Great East Japan earthquake and tsunami. *PloS One* 2014; 9 (7): e102497. <https://doi.org/10.1371/journal.pone.0102497>
45. Lima RC. Distanciamento e isolamento sociais pela Covid-19 no Brasil: impactos na saúde mental. *Physis* 2020; 30 (2): e300214. <https://doi.org/10.1590/s0103-73312020300214>
46. Vergilio CS, Lacerda D, Oliveira BCV, Sartori E, Campos GM, Pereira ALS, et al. Metal concentrations and biological effects from one of the largest mining disasters in the world (Brumadinho, Minas Gerais, Brazil). *Sci Rep* 2020; 10 (1): 5936. <https://doi.org/10.1038/s41598-020-62700-w>
47. Peixoto SV, Asmus CIRF. O desastre de Brumadinho e os possíveis impactos na saúde. *Cienc Cult* 2020; 72 (2): 43-6. <http://dx.doi.org/10.21800/2317-66602020000200012>
48. United Nations. General Assembly. Resolution adopted by the General Assembly on 3 June 2015. 69/283. Sendai framework for disaster risk reduction 2015–2030 [Internet]. 2015 [cited on Jun 26, 2022]. Available at: <https://www.undrr.org/implementing-sendai-framework/what-sendai-framework>
49. Nações Unidas Brasil. Os objetivos de desenvolvimento sustentável no Brasil [Internet]. Brasília: Nações Unidas; 2022 [Cited on Jun 26, 2022]. Available at: <https://nacoesunidas.org/pos2015/agenda2030/>
50. Oliveira WK, Rohlfs DB, Garcia LP. O desastre de Brumadinho e a atuação da Vigilância em Saúde. *Epidemiol Serv Saúde* 2019; 28 (1): e20190425. <https://doi.org/10.5123/S1679-49742019000100025>

## RESUMO

**Objetivo:** Apresentar os aspectos metodológicos do Projeto Saúde Brumadinho e descrever o perfil epidemiológico dos participantes da linha de base da coorte. **Métodos:** Coorte prospectiva, de base populacional, em amostra representativa dos residentes (12 anos ou mais de idade) de Brumadinho, Minas Gerais, após rompimento de barragem de rejeitos de mineração. As informações para a linha de base foram coletadas em 2021, dois anos após o rompimento da barragem de rejeitos de mineração, incluindo aspectos sociodemográficos, de saúde, uso de serviços, entre outros. Foram descritas prevalências de desfechos em saúde em Brumadinho, bem como na região metropolitana de Belo Horizonte e em Minas Gerais, utilizando os dados da Pesquisa Nacional de Saúde de 2019. Todas as análises foram realizadas no Stata 17.0, considerando-se os pesos amostrais e o efeito de delineamento.

**Resultados:** Participaram 3.080 (86,4%) moradores, sendo a maioria do sexo feminino (56,7%) e com média de idade de 46,1 anos. As doenças referidas mais frequentes foram hipertensão arterial (30,1%), colesterol alto (23,1%) e depressão (22,5%). Pelo menos uma consulta médica e uma hospitalização no último ano ocorreram em 75,2% e 9,4% dos entrevistados, respectivamente. **Conclusão:** É importante o monitoramento das condições de saúde, físicas e mentais, após ocorrência de um desastre dessa magnitude. Esse conhecimento poderá contribuir para a gestão de risco desses processos não só no município atingido, mas em outras áreas nas quais as populações estão sob risco de grandes desastres.

**Palavras-chave:** Epidemiologia de desastres. Estudos de coortes. Perfil de saúde. Efeitos de desastres na saúde.

**ACKNOWLEDGMENTS:** Sérgio Viana Peixoto, Josélia O. A. Firmo and Maria Fernanda Lima-Costa are research productivity fellows from the National Council for Scientific and Technological Development (CNPq). The authors would like to thank the Municipal Health Department of Brumadinho and community leaders for supporting the project's activities, as well as the participants of the Brumadinho Health Project, who accepted to be part of the research and dedicated some of their time to this initiative.

**AUTHORS' CONTRIBUTIONS:** Peixoto, S.V.: project administration, formal analysis, data curation, writing – original draft, investigation, methodology, funding acquisition, supervision. Firmo, J.O.A.: project administration, writing – review & editing, methodology, supervision, validation. Fróes-Asmus, C.I.R.: project administration, writing – review & editing, methodology, funding acquisition. Mambri, J.V.M.: formal analysis, data curation, writing – review & editing. Freitas, C.M.: writing – review & editing, methodology. Lima-Costa, M.F.: writing – review & editing, methodology. Souza Júnior, P.R.B.: writing – review & editing, methodology.

**FUNDING:** The Brumadinho Health Project is funded by the Department of Science and Technology of the Secretariat of Science, Technology, Innovation and Strategic Inputs in Health (DECIT/SCTIE) of the Ministry of Health (Process 25000.127551/2019-69) and by Fundação Oswaldo Cruz.

