

## ORIGINAL ARTICLE



## Factors associated with paid work after the dam failure: Brumadinho Health Project

### Fatores associados ao trabalho remunerado após o rompimento da barragem: Projeto Saúde Brumadinho

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## ABSTRACT

**Objective:** To analyze the factors associated with paid work, after the dam failure, based on geographic strata, among men and women residing in Brumadinho, Minas Gerais. **Methods:** Baseline data from participants of the Brumadinho Health Project, aged 18 years or older, obtained through a questionnaire, between July and November 2021 (n=2,783) were used. The dependent variable was paid work after the dam failure and the explanatory variables were geographic stratum, age, education, race/skin color, self-perception of health and employment relationship before the event. The adjusted analysis was estimated by logistic regression. All analyses were performed separately for men and women. **Results:** Paid work after the dam failure was reported by 58.3% (95%CI 55.0–61.6) of the participants, with the highest prevalence among men (71.4%; 95%CI 67.1–75.3) compared to women (48.6%; 95%CI 44.3–52.8) (p<0.001). After adjustments, the results showed that the population who was directly exposed to the disaster was less likely to have a paid work after it, both for women (OR=0.68; 95%CI 0.48–0.95) and for men (OR=0.48; 95%CI 0.30–0.78). In addition, women directly exposed to the disaster and who reported being self-employed before it were less likely to have a paid work, compared to women who reported being employed with or without a formal contract. **Conclusion:** Participation in the labor market is determined by several factors. Thus, intersectoral policies are necessary the population's demands of life and work are met in disaster situations.

**Keywords:** Work. Dams. Health. Educational status.

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## INTRODUCTION

In January 2019, a mining tailings dam under the responsibility of mining company Vale S.A. collapsed in Brumadinho, Minas Gerais. The disaster had direct negative impacts on the health of people and communities affected<sup>1,2</sup>, which, in the medium and long term, can be aggravated by social, economic and occupational problems.

Natural or technological disasters force residents to leave their homes, changing their way of life and work as a result of deterritorialization<sup>3</sup>. Regarding occupational factors, disasters impact agricultural and livestock activities<sup>4,5</sup>, promote the closure of formal workplaces, with consequent unemployment<sup>2,4</sup>, lead to reduced salaries in workplaces<sup>5</sup>, and reduce opportunities for self-employment. As a consequence, individual and family incomes are seriously impaired, also reducing the demand for goods and services, and harming the economic situation of the region as a whole<sup>5</sup>.

It is well established in the literature that, in high- and middle-income countries, the participation of adults and the elderly in the labor market is influenced by factors such as age, skin color, educational level, family composition, income, health conditions, occupation characteristics, and contextual factors<sup>6-8</sup>. These factors accumulate over time and, when added to the consequences of disaster situations, can worsen the living conditions of people, increasing the degree of social vulnerability<sup>4</sup>. It is noteworthy that there are important gender differences in these associations<sup>8,9</sup>. National and international studies have shown that the participation of females in the labor market is still lower than males<sup>6,8,9</sup>, and, in addition to the aforementioned traditional factors, the insertion of women in the labor market is still affected by the presence of children in families and access to social support networks, such as day care centers<sup>6</sup>.

Health is considered the main determinant of work ability<sup>10,11</sup>, and a good ability contributes to long-term working. This ability is the result of a balance between personal factors and working conditions<sup>12</sup>. Understanding which factors are associated with paid work after disaster situations is important to guide health services towards comprehensive and effective care, as well as to support intersectoral policies aimed at people's quality of life and the reestablishment of their occupational/socioeconomic status.

In Brazil, studies on the impact of disasters on the living and working conditions of people and social groups are rare, especially in the medium and long terms<sup>4</sup>. Therefore, the longitudinal study Brumadinho Health Project is an opportunity to explore the topic in the country. The objective of this study was to analyze the factors associated with paid work, after the dam failure, with emphasis on geographic stratum among men and women residing in Brumadinho, Minas Gerais.

## METHODS

### Data Source and Sample

The present study used data from baseline participants of the Brumadinho Health Project, which is a prospective cohort study coordinated by Fundação Oswaldo Cruz in Minas Gerais (Fiocruz Minas) and by Universidade Federal do Rio de Janeiro (UFRJ), in order to evaluate the living and health conditions of people living in the municipality of Brumadinho after the great collapse of the mining tailings dam.

The project's sampling plan was designed to represent the population residing in the municipality of Brumadinho and aged 12 years and over. In addition, the objective was to obtain information from three geographic strata, namely:

1. Region directly exposed to the tailings dam failure at the mine *Córrego do Feijão*, that is, households located in communities directly affected by the tailings mud from the dam or residing near the *Paraopeba* River, immediately after the mud reached its course;
2. Areas with mining activity, that is, the community in which mining activity is constant; and
3. Region not directly exposed to the dam failure or with mining activity, that is, the rest of the municipality made up of communities without mining activity and not affected by the tailings dam collapse.

All households located in the directly exposed and mining regions were invited to participate in the research, in addition to a random sample of households located in other regions of the municipality (not directly exposed). A total of 1,446 households were visited and 3,249 adults were eligible for the study, of which 2,805 (86.3%) responded to the questionnaire. Data collection was carried out at the participants' households by means of the questionnaire, applied by trained interviewers, between June and November 2021. More details are available in another publication<sup>13</sup>. The Brumadinho Health Project was approved by the Research Ethics Committee of Fiocruz Minas (20814719.5.0000.5091), and all participants signed the Free and Informed Consent Form (ICF) and/or the Free and Informed Assent Term of the Underage, accompanied by the ICF signed by their caregivers.

All adult participants (18 years of age or older) who were part of the baseline cohort of the project (n=2,805) were eligible for the present analysis.

### Study Variables

The dependent variable was reported paid work after the dam failure, to the question: "after the dam failure, do/did you have a paid employment, even if only for a while?". Paid work was considered the performance of activities to earn money, including salary, personal withdrawal from an enterprise, income as a self-employed worker, etc. For the present analysis, paid vacations and leaves of absence were considered paid work.

The explanatory variables included geographic stratum (region not directly exposed, region directly exposed and area with mining activity), age (18 to 45 years, 46 to 59 years, and 60 years and older), education (primary/elementary school, high school/higher education or more), self-reported race/skin color (categorized as white and non-white — which encompasses black, brown, yellow and indigenous races), self-perception of health (with the question “in general, how do you rate your health?”), categorized as fair/poor/very bad and good/very good; and type of employment relationship before the dam failure, by means of the question “considering your life until the year 2018 (before the dam failure), would you say that, most of the time you were — unemployed, formally employed, working informally or self-employed” (encompassing being owner of a rural or urban establishment, working in family business, or without a fixed salary).

### Data Analysis

Participants' characteristics were described using estimates of proportions to assemble the total sample and according to sex. Association between categorical variables and paid work after the dam failure was evaluated by the  $\chi^2$  test with Rao-Scott correction. Adjusted effect estimates

were based on odds ratios (OR) and respective 95% confidence intervals (95%CI), calculated by binary logistic regression. Then, interactions between the geographic stratum and variables age, self-perception of health and type of employment relationship were tested. The predicted probability of having a paid work after the dam failure, according to geographic stratum and type of employment, was estimated based on the model adjusted with all variables included in the study. Analyses were performed separately for men and women. The statistical package Stata 14.0 was used, considering the effect of the study design and sample weights.

## RESULTS

Among 2,805 adult individuals (aged 18 years or older) from the Brumadinho Health Project baseline sample, 2,783 provided complete information for the variables of interest and were included in the study. Of the total sample, 58.3% (95%CI 55.0–61.6) reported having a paid work after the dam collapse, with the highest prevalence among men (71.4%; 95%CI 67.1–75.3) compared to women (48.6%; 95%CI 44.3–52.8) ( $p < 0.001$ ).

Table 1 lists the characteristics of the study participants according to sex and work status. The mean age of partici-

**Table 1. Sociodemographic characteristics, self-perception of health and type of employment relationship before the dam failure, according to sex and work status after the dam failure. Brumadinho Health Project (MG), 2021.**

Variables	Total (%)*	Women Paid Work		p-value <sup>†</sup>	Men Paid Work		p-value <sup>†</sup>
		No (%)*	Yes (%)*		No (%)*	Yes (%)*	
Geographic stratum							
Not directly exposed	95.5	95.6	96.1	0.374	95.2	95.1	0.247
Directly exposed	2.9	2.8	2.4		3.5	3.1	
Mining activity area	1.6	1.6	1.5		1.3	1.8	
Age (years)							
18-45	43.9	30.8	58.9	<0.001	21.3	51.9	<0.001
46-59	25.6	22.5	28.0		8.5	33.2	
60 and older	30.5	46.7	13.1		70.2	14.9	
Current educational level							
Primary/elementary school	53.5	63.9	35.4	<0.001	69.9	53.4	<0.001
High school/higher education or more	46.5	36.1	64.6		30.1	46.6	
Race/skin color							
White	42.6	46.6	43.1	0.412	48.0	36.2	0.017
not white	57.4	53.4	56.9		52.0	63.8	
Self-perception of health							
Fair/poor/very bad	37.7	48.2	33.7	<0.001	48.2	27.1	<0.001
Good/very good	62.3	51.8	66.3		51.8	72.9	
Type of employment relationship before the dam failure							
Unemployed	22.3	44.6	11.3	<0.001	32.8	6.5	<0.001
Employed, formal contract	39.6	21.6	41.4		41.4	54.8	
Employed, without a formal contract	18.7	20.5	24.5		7.6	16.2	
Self-employed	19.4	13.3	22.8		18.2	22.5	

\*Percentage weighted by sample parameters; <sup>†</sup>P-value from  $\chi^2$  test with Rao-Scott correction.

pants was 46.4 years (SD=17.4), most were women (57.2%), with complete primary/elementary school (53.5%), non-white race/skin color (57.4%) and perceived their own health as good (62.3%). Of the participants, 39.6% reported having a formal employment before the dam collapse. For both sexes, having a paid work after the dam failure was significantly associated with age, educational level, self-perception of health, and type of employment relationship before the dam failure. Only among men, having a paid work after the dam failure was significantly associated with race/skin color.

In the adjusted analysis shown in Table 2, the directly exposed population had a lower chance of having a paid work after the dam failure, for both women (OR=0.65; 95%CI 0.46–0.90) and men (OR=0.48; 95%CI 0.30–0.78). In terms of age, older participants (60 years and older) were less likely to have a paid work after the dam collapse, for both sexes (OR=0.11; 95%CI 0.06–0.20 among women; OR=0.05; 95%CI 0.02–0.10 among men). It is noteworthy that, only among women, the age group from 46 to 59 years was also related to a lower chance of having a paid work (OR=0.46; 95%CI 0.28–0.73). This outcome was also associated with higher levels of edu-

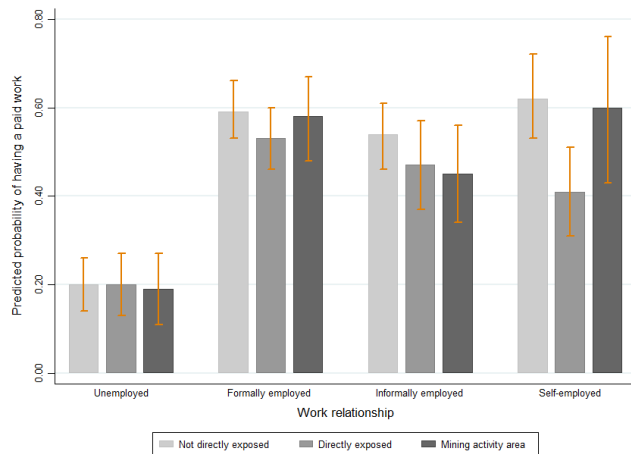
cation (high school/higher education or more) for both sexes (OR=2.25; 95%CI 1.53–3.32 among women; OR=2.70; 95%CI 1.57–4.64 among men). Only among men, the perception of health as good/very good was significantly associated with having a paid work after the dam failure (OR=2.08; 95%CI 1.26–3.41). Regarding the type of employment relationship, participants who reported being self-employed before the dam failure were more likely to have a paid work after the event, mainly among men (OR=22.72; 95%CI 7.90–65.41) compared to women (OR=9.88; 95%CI 5.29–18.47).

The results also showed that, only among women, there was a significant interaction ( $p<0.05$ ) between geographic stratum and type of employment relationship. Thus, women directly exposed to the dam failure, who reported being self-employed before the dam failure, were less likely to have a paid work after the event, compared to women who reported not working, or having a formal or informal employment. Figures 1 and 2 show the predicted probability of having a paid work after the dam collapse, according to geographic stratum and type of employment relationship for women and men, respectively.

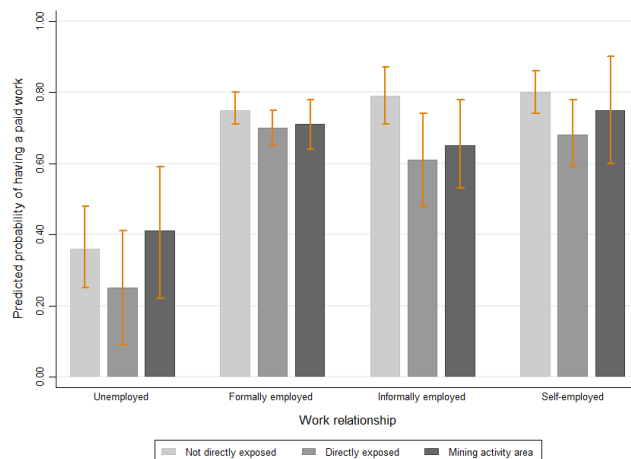
**Table 2. Adjusted associations between having a paid work and sociodemographic characteristics, self-perception of health and type of employment relationship before the dam collapse, according to sex. Brumadinho Health Project (MG), 2021.**

Variables	Women		Men	
	OR	95%CI	OR	95%CI
Geographic stratum				
Not directly exposed	1.00		1.00	
Directly exposed	0.65	0.46–0.90	0.48	0.30–0.78
Mining activity area	0.82	0.57–1.17	0.66	0.37–1.19
Age (years)				
18–45	1.00		1.00	
46–59	0.46	0.28–0.73	1.05	0.49–2.25
60 and older	0.11	0.06–0.20	0.05	0.02–0.10
Current educational level				
Primary/elementary school	1.00		1.00	
High school/higher education or more	2.25	1.53–3.32	2.70	1.57–4.64
Race/skin color				
White	1.00		1.00	
not white	1.04	0.69–1.55	1.61	0.93–2.79
Self-perception of health				
Fair/poor/very bad	1.00		1.00	
Good/very good	1.26	0.86–1.83	2.08	1.26–3.41
Type of employment relationship before the dam failure				
Unemployed	1.00		1.00	
Employed, formal contract	8.55	5.14–14.22	15.22	6.51–35.59
Employed, without a formal contract	6.36	3.65–11.10	20.43	7.07–59.00
Self-employed	9.88	5.29–18.47	22.72	7.90–65.41

Sample: 2,783 (1,509 women; 1,274 men); OR: odds ratio estimated by binary logistic regression and adjusted for all variables listed in the Table; 95%CI: 95% confidence interval.



**Figure 1. Predicted probability of having a paid work after the dam failure among women, according to geographic stratum and type of work relationship. Brumadinho Health Project (MG), 2021.**



**Figure 2. Predicted probability of having a paid work after the dam failure among men, according to geographic stratum and type of work relationship. Brumadinho Health Project (MG), 2021.**

## DISCUSSION

Our findings indicate that the participation of men in the labor market was higher compared to women. In the analysis stratified by sex, among both men and women, the probability of having a paid work after the dam failure was lower for participants directly exposed to the dam failure and for those aged 60 years and older. In addition, it was higher for men and women with a higher level of education (high school/higher education or more) and among those who reported being self-employed before the dam collapse. Finally, only among men, the chance of having a paid work after the dam failure increased for those who perceived their health as good/very good. In the interaction analysis, for women only, the probability

of having a paid work after the dam failure decreased significantly among those directly exposed to the event and who reported being self-employed, compared to women who reported having a formal or informal employment before the dam failure.

Despite the undeniable advances in the situation of women in the labor market, the participation of men is stronger, especially in developing countries<sup>14-17</sup>. Women still have a higher unemployment rate<sup>16</sup>, a greater probability of working double shifts<sup>18</sup> and of an informal employment or being self-employed<sup>15</sup>. Vulnerability situations experienced by society, such as the collapse of the tailings dam at the mine Córrego do Feijão, make working conditions scarcer and more precarious, especially for women, intensifying gender inequalities<sup>14,19</sup>. Our findings corroborate these data by showing the lower chance of having a paid work among women.

Regardless of gender, participants residing in regions directly affected by the dam failure were less likely to have a paid work after the disaster, compared to residents in other strata. It can be explained by the territorial extension of the municipality affected by the tailings mud<sup>1</sup>, leading to the destruction of several jobs, and by health-related problems that interfere with one's insertion in the labor market<sup>9</sup>. This study does not allow inferring whether the lower prevalence of paid work after the dam collapse was already present in the directly exposed region or if it was a consequence of the event.

Chronological aging compromises the ability to work. The first decline in capacity occurs around age 45<sup>20</sup>. The lower probability of older people (60 years and over) reporting to have a paid work after the dam collapse is in line with the findings of previous studies<sup>9</sup>. However, studies have shown that the contingent of elderly workers has been increasing more sharply, as there is a decrease in the number of elderly people leaving the workforce after legal retirement age<sup>21</sup>. Given the aging of the population, adjustments are expected both in organizations and in production processes, with broad discussion on work relationships involving the elderly, in order to reduce discrimination, vulnerability and social exclusion, facilitating their entry and permanence in the labor market<sup>22</sup>. Additionally, the results of this study showed that, only among women, the age group from 46 to 59 years old also had a lower chance of having a paid work after the dam collapse. This could be explained by the fact that, at advanced ages, women have double vulnerability (age and sex), which makes it difficult to enter the labor market, or by the double shift matter, that puts in question the permanence in the labor market for a significant percentage of women<sup>18</sup>.

Our study showed that men and women with higher levels of education were more likely to have a paid work after the dam failure. Regardless of other factors, higher education enables better professional qualification and,

consequently, expands access to paid work and better working conditions<sup>15,17</sup>.

Regarding health, only among men a perception of good/very good health was more likely to have a relation to paid work after the dam collapse. This result corroborates a previous study, conducted with a national sample representative of the Brazilian population aged 50 years or over, which showed, based on a structural equation modeling analysis, that the strength of the association between lifetime health status and paid work was twice as high for men than for women. The authors state that it can be explained by the fact that men tend to perform more physically demanding tasks throughout their lives when compared to women<sup>9</sup>.

Finally, the results showed a modification of the association between geographic strata and different types of employment agreements before the dam failure with paid work after the dam failure only among women. That is, women directly exposed to the disaster and who reported being self-employed before the collapse were less likely to have a paid work after it, compared to women directly affected, but who reported other types of work agreement (unemployed, formal or informal employment). Data from the Institute of Applied Economic Research (IPEA 2022)<sup>23</sup> attest a marked upward trend in informal work (23.6%), followed by formal work (14.6%) and, finally, by self-employment (9.8%). Worldwide, more than 42% of workers are self-employed, which is classified as “vulnerable employment” by the International Labor Organization (ILO)<sup>15</sup>. Self-employed workers are more likely to live in poverty or have limited access to social protection systems. According to ILO data, self-employment does not seem to be an important step towards better opportunities in the labor market. These people are unlikely to expand their activities and become employers<sup>15</sup>.

Gender inequality facilitates the entry of women into the informal labor market and self-employment world, with unstable remuneration and few guarantees of labor rights<sup>14</sup>. Added to this, the situation of occupational, economic and social vulnerability of women can be aggravated in disaster situations, as our study shows. In this sense, actions to promote gender equality must be implemented and strengthened, as they are related to greater participation of women in the formal labor market, to smaller disparities in wages, to a larger number of women in managerial positions, at higher levels of entrepreneurship, with consequent increase in productivity and well-being, enabling them to get out of vulnerability situations<sup>24</sup>.

Among the limitations of the study, we can mention the cross-sectional analysis and the definition of the outcome, which considers the work situation of participants only after the failure, not allowing one to infer a temporal relationship between the variables or to attribute the situation to the dam failure. The variable work situation before the dam collapse alone can portray a temporality, but it may

carry information bias, considering that the data were collected two years after the disaster. Despite this, few studies in the health area have examined the factors associated with paid work status of men and women after disasters such as the collapse of the tailings dam at the mine Córrego do Feijão. The present study, being population-based and conducted with a sample representative of the municipality, portrays the most vulnerable groups due to the absence of work, which may help in decision-making.

According to our findings, participation in the labor market is determined by several factors such as gender, educational level, self-perception of health, and employment relationship. After disaster situations such as the one that occurred in Brumadinho, it is essential that intersectoral policies are implemented, aiming at better living and working conditions, including investment in education, qualification of health professionals, expansion of jobs, flexible working hours, investments in occupational sectors that are important generators of jobs in the municipality, among others. This broader look at the situation experienced after the dam collapse will allow one to identify the situations of vulnerability the population is exposed to and to propose effective actions, especially aimed for women.

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## RESUMO

**Objetivo:** Analisar os fatores associados ao trabalho remunerado, após o rompimento da barragem, com ênfase no estrato geográfico, entre homens e mulheres residentes em Brumadinho, Minas Gerais. **Métodos:** Foram utilizados dados dos participantes da linha de base do Projeto Saúde Brumadinho, com 18 anos ou mais de idade, obtidos por aplicação de questionário, entre julho e novembro de 2021 (n=2.783). A variável dependente foi trabalho remunerado após o rompimento da barragem, e as variáveis explicativas foram estrato geográfico, idade, escolaridade, raça/cor, autopercepção de saúde e vínculo de trabalho antes do rompimento da barragem. A análise ajustada foi estimada pela regressão logística. Todas as análises foram realizadas separadamente para homens e mulheres. **Resultados:** O trabalho remunerado após o rompimento da barragem foi relatado por 58,3% (IC95% 55,0–61,6) dos participantes, sendo a maior prevalência entre os homens (71,4%; IC95% 67,1–75,3) em comparação às mulheres (48,6%; IC95% 44,3–52,8) (p<0,001). Após ajustes, os resultados mostraram que a população diretamente exposta apresentou menor chance de ter trabalho remunerado após o rompimento da barragem, tanto para as mulheres (OR=0,68; IC95% 0,48–0,95) quanto para os homens (OR=0,48; IC95% 0,30–0,78). Além disso, mulheres diretamente expostas ao rompimento da barragem e que relataram trabalho autônomo antes do rompimento apresentaram menor probabilidade de ter trabalho remunerado, em comparação àquelas que informaram trabalhar com ou sem carteira assinada. **Conclusão:** A participação no mercado de trabalho é determinada por vários fatores. Dessa forma, políticas intersetoriais são necessárias para atender às demandas de vida e trabalho da população em situações de desastre.

**Palavras-chave:** Trabalho. Barragem. Saúde. Escolaridade.

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