

Mining and Mental Health – The Effects of the Fundão Dam Collapse

Georgina Maria Vêras Motta¹, Livia de Oliveira Borges²

¹ <http://orcid.org/0000-0002-1005-2205> / Universidade Federal de Minas Gerais (UFMG), Brasil

² <http://orcid.org/0000-0003-2251-1373> / Universidade Federal de Minas Gerais (UFMG), Brasil

Abstract

We compared the living and working conditions and mental health between miners who worked in Mariana when the Fundão dam broke, to other miners who worked in another city. We based our work on the ecological, social causation, biopsychosocial models, and other contributions. We applied the General Health Questionnaire-12, Rosenberg's self-esteem scale, and the Work-Family Conflict scales to 164 miners, interviewing 25 of them. We observed that the living and working conditions of the miners of Mariana differ unfavorably and are more prone to common mental disorders. The impoverishment of the social environment, the loss of social support, the increasing conflicts in families, the attribution of guilt for the dam collapse, and the economic decline of the city contributed to accentuating feelings of malaise, depression, and anxiety.

Keywords: mining, mental health, occupational accident.

Mineração e Saúde Mental – Os Efeitos do Rompimento da Barragem de Fundão

Resumo

Comparamos as condições de vida, de trabalho e a saúde mental dos mineiros que trabalhavam em Mariana quando se rompeu a barragem de Fundão com as de outros que trabalhavam em outra cidade. Baseamo-nos nos modelos: ecológico, de causação social e biopsicossocial. Aplicamos o Questionário de Saúde Geral-12, as escalas de Autoestima de Rosenberg e de Conflito Trabalho-Família a 164 mineiros e entrevistamos 25 deles. Observamos que as condições de vida e de trabalho dos mineiros de Mariana diferem desfavoravelmente e estão mais sujeitos a transtornos mentais comuns. O empobrecimento do meio social, a perda de apoios sociais, os conflitos crescentes na família, a atribuição de culpa pela ruptura da barragem e a decadência econômica da cidade contribuíram para acentuar os sentimentos de mal-estar, depressão e ansiedade.

Palavras-chave: mineração, saúde mental, acidente de trabalho.

Minería y Salud Mental – Los Efectos de la Ruptura de la Presa de Fundão

Resumen

Comparamos las condiciones de vida y de trabajo y la salud mental de los mineros que trabajaban en Mariana cuando se rompió la presa de Fundão con las de otros que trabajaban en otra ciudad. Para eso, nos basamos en los modelos: ecológico, de causación social y biopsicossocial. Aplicamos el Cuestionario de Salud General (GHQ-12), las escalas de Autoestima de Rosenberg (RSE) y de Conflicto Trabajo-Familia a 164 mineros y entrevistamos 25 de ellos. Observamos que las condiciones de vida y de trabajo de los mineros de Mariana difieren desfavorablemente y que ellos están más susceptibles a trastornos mentales comunes. El empobrecimiento del medio social, la pérdida de apoyos sociales, los crecientes conflictos en la familia, la atribución de culpa por la ruptura de la presa y la decadencia económica de la ciudad contribuyeron para reforzar los sentimientos de malestar, depresión y ansiedad.

Palabras clave: minería, salud mental, accidente laboral.

Brazil is one of the world's leading exporters of minerals. In the first semester of 2020, the export of iron ore (the second in the world) represented 82% of the country's total mining exports and 9.3% of Brazilian exports (Brasil, 2020b). In this period, the state of Minas Gerais (MG) ranked second (38%) in the Royalties for the Exploitation of Mineral Resources, (CFEM, Financial Compensation for the Exploration of Mineral Resources). According to the Instituto Brasileiro de Mineração (IBRAM, 2020) in 2019, it was the state with the highest percentage (31.6%) of direct jobs in mining (62,667 workers), about three and a half times the number of jobs in the mineral processing industry and up to eleven times the number of direct workers in the production chain. Therefore, mining is a relevant activity that generates jobs in the state. It has a mean income of BRL 3,438.44, which is above the Brazilian mean, BRL 1,638.33 (Brasil, 2020a).

However, this economic performance contrasts with physical illnesses and psychological suffering related to mining work (Minayo, 2004; Moulin & Moraes, 2010; Parreiras, 2017; Seaton, Bottorff, Oliffe, Medhurst, & DeLeenheer, 2019). This situation is probably accentuated among the miners of the city of Mariana (MG), Brazil, after the collapse of the Fundão tailings dam, on November 5, 2015. It destroyed the district of Bento Rodrigues (Mariana), caused 19 deaths, injured 256 people, and damaged 33 cities, in the 700 km course that the 34,000,000 m³ of mining tailings traveled toward the Atlantic Ocean (Azevedo & Freitas 2019; Santos & Wanderley, 2016). Studies after the collapse, such as the ones carried out by Azevedo and Freitas (2019), and Motta and Borges (submitted), found the existence of psychic changes and low prevalence of psychological well-being among these miners. We asked if these sufferings are specific to the miners who experienced such an event.

We then carried out this study with the objective of comparing miners who worked in Mariana when the dam broke with others who worked in another city, in terms of working and living conditions, as well as mental health. For the second city – Conceição do Mato Dentro (CMD) – mining was also an important sector of its economy. Both cities are in the state of Minas Gerais and were founded in the Brazilian colonial period as a result of gold mining (Dias & Oliveira, 2018; Rosa, 2019).

The first city, Mariana, is in a region known as the iron quadrilateral, a place of economic and social relevance. In 2017, its GDP per capita was BRL 48,407.28 (IBGE, 2020). It reduced its municipal tax collection in 2017 (BRL 40.7 million) compared to 2013 (BRL 89.6 million), attributing such CFEM reduction to the crisis that followed the Fundão dam collapse (Prefeitura Municipal de Mariana, 2019). The second, CMD, is located in the Serra do Espinhaço. In 2017, it registered a GDP per capita of BRL 44,742.28 (IBGE, 2020), which possibly increased, given its growing mining production since, in 2020, it was the city with the highest quarterly CFEM collection in the state and the third in Brazil (Brasil, 2020b).

Mental Health and Work: Theoretical Framework

The definition of health has evolved from its conception as the absence of interrelationship between the biological and psychic and social events (Melo, Cavalcante, & Façanha, 2019) to the positive concept – a complete physical, mental, and social well-being – and not consisting only of the absence of illnesses. The latter, proposed by the World Health Organization in 1948 (WHO, 2006), broke the paradigm of the health-illness opposition, introduced psychic and social aspects, and proposed an integral view of the human being. However, there are difficulties in applying it due to its breadth and lack of measurable indicators

(Benavides, Ruiz-Frutos, & Garcia, 2004).

Consequently, we incorporated contributions from authors (such as Batistella, 2007; Benavides, Declós, & Serra, 2018a; Benavides et al., 2004; Canguilhem, 2009) to the WHO concept that recognize the involvement of individuals in the process of illness, prevention, and treatment, as well as the State's responsibility in developing public policies. They approach health as being multi-dimensional and dynamic, influenced by socio-cultural, environmental, and economic factors, enabling the development of measurable indicators, considering living and working conditions as antecedents (Batistella, 2007; Benavides, Declós & Serra, 2018b; Canguilhem, 2009; Llosa-Fernandes, Menéndez-Espina, Agulló-Tomás, & Rodríguez-Suárez, 2018; Melo et al., 2019; Mirowsky & Ross, 1989; Warr, 1987).

Compatible with this conception of health and work, F. R. C. Fernandes, Araújo, and Olivieri (2014), focusing on the mining sector, signaled the potential of contamination by dangerous substances, heavy metals, and radioactive substances, the socioeconomic impacts (e.g., increase in violence) and environmental issues, such as water, soil, and air pollution and the collapse of dams. Such risks affect different types of populations, including traditional communities. Parreiras (2017), in turn, warned of health problems for miners due to exposure to physical, chemical, and fire and explosion risks, accidents, and factors resulting from the organization and work processes. These injuries are not independent of psychological suffering and illness (Ansoleaga & Toro, 2010; Minayo, 2004; Moulin & Moraes, 2010; Motta & Borges, submitted). Seaton et al. (2019) considered the presence of a culture of toxic masculinity, presuming this kind of work as a hard one and, at the same time, rejecting the expression of stress or mental health problems.

These mining characteristics are antecedent aspects in explanatory mental health models, namely: ecological, social causation, and biopsychosocial models. Warr (1987), when proposing the ecological model, contemplated the positive conception of health, describing mental health in five dimensions:

- a) Affective well-being, resulting from the relationship/combination of pleasure and excitement.
- b) Personal competence, related to the person's ability to deal with environmental pressures and solve problems.
- c) Autonomy, defined by the person's ability to deal with the influences of the environment and develop their own opinions and actions.
- d) Aspiration, related to the person's interest and involvement with the environment and in establishing goals and means to achieve them.
- e) Integrated functioning, defined by the balance and/or conflict between the functioning of different social roles (work and/or employment, leisure, and family relationships).

According to Warr (1987), self-esteem reflects the assessment of indicators of competence, autonomy, and aspiration, as these are feelings that jointly self-direct contribute to an opinion about oneself (self-esteem). The environment influences mental health dimensions from nine aspects: opportunity to exercise control over the environment, opportunity for skill use, externally generated goals, variety of tasks and/or activities, environmental clarity (information), availability of money, physical security, opportunity for interpersonal contact, and valued social position. Individual differences, such as personal and/or social values and skills, intrinsically related to the work content, can mediate the influences of the environment.

Mirowsky & Ross (1989) assumed that differences in social position (related to income, educational level, gender, race, ethnicity, and marital status) contribute to the process of

elaborating beliefs and valuing assumptions about society and human relations. Three core aspects influence individual and social malaise patterns, namely:

a) Alienation, seen as a rupture in social identity, is expressed in five basic types: impotence (an objective impossibility in reaching personal goals), self-estrangement (perception of third parties controlling their thoughts, actions, and experiences), isolation (distance from the social interaction), the lack of meaning (unknowable perception of the world and the purpose of life), and the lack of norms (rejection of social patterns of behavior).

b) Authoritarianism, the perception of the world limited to the values of individuals' personal networks, considered as universal and unique, above any other, regardless of time, place, and situation.

c) Inequality, characterized by the power gap in relationships, favors social injustices and generates anxieties such as violence and guilt linked to the perception of being a victim or exploiter.

Mirowsky and Ross (1989) treated these aspects as links between objective social conditions and subjective suffering. It converges to the ecological model of Warr (1987), among other aspects, for explaining health from the relationship between people and the social environment and for including the social position among the environmental factors.

In the biopsychosocial model, Marchand and Durand (2011) incorporated, among the antecedent variables of mental health, work and its conditions, the family, and community aspects. They also signaled the moderating and controlling role of aspects such as: psychosocial conditions (gender, life cycle, stressful vital events, and psychic traits), economic variables (related to the company and the markets), and unionization. However, like Martín (2010), despite contributing to the recognition of the nexus between work and health, covering the mental health background aspects of different levels of analysis, from individual to societal, they considered only changes or psychic disorders as health indicators. Such models apprehend distinct and complementary aspects of the relationship between mental health and work and, as a whole, expand the possibility of analysis.

Method

We structured the research into two complementary strategies: 1) mapping the workers' mental health conditions at the time of the research, through structured questionnaires; 2) understanding the workers' perception about the impacts experienced at work and in their lives by the Fundão dam collapse, using semi-structured interviews. We performed field activities in two periods: the first from August to September 2018, in Mariana, and the second from April to May 2019, in CMD.

Participants

A total of 163 mining workers answered a questionnaire, 109 individuals (102 men and seven women) working in Mariana at the time of the Fundão dam collapse and 54 (44 men and 10 women) working in CMD. The sample had a mean age of 39 years old ($SD = 10.4$) and 13.4 years ($SD = 3.6$) of formal education, with 12.3% still studying. The mean time in the current activity was 26.4 months ($SD = 46.4$), and 79.0 months ($SD = 82.7$) in their previous professional activities. Regarding their current professional activities, 57% declared to be working in mining activities and 11.7%, other activities. The remaining participants were self-employed (8.6%), informal workers (9.8%), while others had retired (5.5%) or were unemployed (7.4%).

Regarding their previous professional activities, 84.6%

declared themselves to be miners, 1.2% self-employed, 13.5% in other activities, and 0.6% unemployed. Regarding marital status, 67.5% of participants were married or living in a stable relationship, 63.7% had children, and 72.9% had dependents.

We interviewed 25 workers from the total number of participants (24 men and one woman), including 15 workers from the company that owns the Fundão dam and four miners from CMD. Regarding age, two were under 30 years old, 23 were between 31 and 50 years old, and four were over 51 years old. Regarding marital status, 16 were married, five participants were in a stable union, and four were single or separated. Seven had worked in mining activities for five years, six had worked between 6 and 10 years, five between 11 and 20 years, two between 21 and 30 years, and five for over 30 years. Among the interviewees, 15 were born in Mariana or in the region, seven in other locations, two in another state, and one considered himself as being born in Mariana. Concerning the last positions held in the mining sector, 14 were in medium-rank operational positions (such as mobile equipment operators, belt operators, mechanics), three in technical operational positions (as pipeline station technicians, industrial maintenance technicians, physical laboratory technicians), and eight worked in administration (as storekeepers, team leaders). During the survey period, fifteen of them were employed in mining, six in other activities, six were unemployed, and two were performing informal activities.

Instruments

Structured questionnaires. To understand the participants' mental health conditions, we chose questionnaires based on the mental health indicators of Warr's model (1987) and included a measure of psychic disorders, considering studies by other authors (e.g., C. Fernandes & Pereira, 2016; Kotera, Green, & Sheffield, 2019; Marchand & Durand, 2011; Martín, 2010; Palma Contreras, Ahumada Muñoz, & Ansoleaga Moreno, 2018; Rabelo, Silva, & Lima, 2018; Seaton et al., 2019). We applied the following questionnaires:

a) General Health Questionnaire-12 (GHQ-12), used to measure common mental disorders and function as an inverted measure of affective well-being. Created in 1972 by Goldberg, it is recommended for screening cases (Sá Junior & Wang, 2016), reputable in epidemiological research (Banks et al., 1980; Borges & Argolo, 2002). We used the unifactorial solution of the occupational use version (Borges & Argolo, 2002), whose answers range from 1 to 4.

b) Rosenberg's Self-esteem Scale (RSES) to analyze self-esteem for, according to Warr (1987) indicators of competence, autonomy, and aspiration are interdependent and synthesized by self-esteem. We used the version adapted by Hutz and Zanon (2011), a one-dimensional measure, with ten items related to feelings about oneself, positive (self-esteem) or negative (depreciation), whose answers vary from 1 to 4.

c) Work-Family Conflict Scale to estimate the Work to Family Interference (WFI) and Family to Work Interference (FWI), that is, mutual impacts between the roles played in family and work situations, as we consider them as indicative of integrated functioning (Warr, 1987). Netemeyer, Boles, and McMurrianem created this scale in 1996. Aguiar and Bastos (2013) translated and adapted it for use in Brazil. It provides answers according to a Likert scale, ranging from 1 to 6.

Interview script. The semi-structured script covered 22 questions, about: 1) the living and working conditions in the cities where these mining companies were operating; 2) the worker's experience of a breaking dam and its impacts on work and life;

3) the psychosocial context and its repercussions on work, health, and life expectations. The script and the development of the interviews were guided by Warr's health indicators (1987) and the environmental aspects of the previously mentioned models.

Data Collection Procedures And Ethical Considerations

After the dissemination of the survey in the electronic media of mining unions, we applied the questionnaires and conducted individual interviews. We applied both techniques, under voluntary authorization of each participant in this research, with care to maintain his/her anonymity. In Mariana, we performed them in the unions' office: the Metabase Mariana Syndicate and the Metabase Inconfidentes Syndicate. In CMD, we adopted the snowball technique to access workers and the participants chose the locations of the activities.

We recorded the answers to the questionnaires in a palmtop-like computer (Pocket PC), compatible with the Statistical Package for Social Science (SPSS) software, which we used to estimate the scores of all factors of the scales, for the statistical analyzes of sample characterization and the others necessary to reach the research objective.

We recorded the interviews under the authorization of each participant, and transcribe them in full. In the literal excerpts we used in the presentation of the results, we removed any details that would allow the identification of the participant and used the letter "I" (interviewee) followed by the assigned number. For analysis, we adopted Minayo's (2014) orientation of articulating categorical content analysis (Bardin, 2011) with hermeneutic-dialectical reflection, aiming to simultaneously contemplate the historicity of the identified meanings, ruptures, and contradictions.

Data Analysis Procedures

To organize the material and the codifications, we used the QDA Miner software. We started with floating reading (Bardin, 2011; Turato, 2003), understanding the characteristics that would allow us to outline the categories and define the analysis corpus (Turato, 2003), and identifying the nuclei of meaning (Bardin, 2011). We gathered these groups in more synthetic categories, trying to understand the historical meanings and contextualize them with the results of the questionnaires, the documentary information, and the specialized literature.

Results

Result of the Interviews

We organized the results of the interviews as addressed in the script, the contextualization of living and working conditions in both cities, the experience of a breaking dam, the psychosocial context, and the repercussions on work, health, and life.

Living and working conditions in the cities of CMD and Mariana. The CMD office is small, "I liked the city (...) I am from a small city in Bahia, right? (...) It reminded me of (...) the city I used to live in (...) (I23). According to this participant "CMD has the advantage of being the cradle of tourism in the state of Minas Gerais, with several waterfalls (...) The Tabuleiro waterfall, (...) One of the largest in Brazil (...) they don't explore this part here" (I25). Another reported: "I always heard my father's stories (...) People here are suffering, they were always exploited (...) practically slave labor (...) In exchange for food, clothes" (I26).

Some participants stated that the company contributed to the development of the city: "I think what really came to have an

impact, economically, was the company. (...). Apart from mining we have small jobs, some stores, that sort of thing (...) practically, mining is what maintains the whole region" (I25). An interviewee highlighted "people (...) who had their first job (...) first car (...) built houses because of mining" (I23). Another interviewee, however, pointed out deficiencies "Leisure, health, education also have some difficulties (...) some things are lacking, do you get it?" and comments "today I have some difficulties here, in being here alone, without my family because of that" (I24).

Despite the benefits, a participant acknowledged the negative impacts of mining: "Mining, it is really (...) like many others, like livestock and everything has deforestation, there is a lot. (...). Progress has a price, right? " (I23). And another signaled that there is a conflict with the population: "the population accepting and knowing that mining is a way of exploitation (...) It is an inheritance from gold mining, which we used to have, from charcoal, (...) wood". And added: "I think that putting the mining companies together with people, and having this information more aligned, I think it could be much better" (I26). They affirmed the responsibility for inspection by the government to prevent further damage: "We have agencies that control this, right? We have laws to comply with" (I23). Another participant adds: "I think that every inspection (...) Is an inspection ... by surprise" (I26).

Mariana, according to an interviewee, is "a very old, beautiful, a historic city and ... that has always survived, right ... with more resources from mining itself" (I1). Another participant stated: "a very prosperous region of employment since my childhood" (I5). According to an interviewee "the city used to be full of people from other cities, sometimes from other states" (I16). Currently they are experiencing the opposite, due to the dam collapse, according to a participant: "today the city is a chaos (...) Of unemployment, due to the basic conditions that we do not have ... (...) A lot of unemployment, violence has increased a lot (...) in this precarious situation "(I17).

In both cities, the contractual and legal conditions practiced by the mining companies were similar. The company in CMD and the owner of the Fundação subsidiary adopted the Brazilian private contracting regime, the Consolidação das Leis do Trabalho (Consolidation of Labor Laws), with Profit and Results Sharing (PRS), the workers' right to a share of the economic result (Brasil, 2000). They encouraged people to study, as the Mariana participants reported: "it [the company] paid up to 80% of our studies" (I10), and "let's move, let's grow" (I21). Similarly, a CMD participant commented on the intention of the employing company: "they wanted us to study, to go to college (...) always specializing (...) to facilitate our growth within the company" (I23).

Regarding the benefits provided to their workers, there were similarities. Both provided health care (medical and dental), free of charge, to the interviewees. However, only the Mariana workers reported additional benefits during the Christmas holidays or the existence of a credit cooperative, job stability and the incentive to an extended career (Motta & Borges, submitted).

The mining processes were similar. Both companies adopted standard operating procedures. The two groups considered shift work uncomfortable, by to physical complaints: "there is fatigue, tiredness. As we work shift after shift, we change our lifestyle all the time", and for hindering social and family relationships as interviewed: "I could be spending time with my family, son (...) you can't, you have to be sleeping, to get ready for the night shift" (I24).

Both groups reported that mining is a high-risk activity, "level 4 risk" (I15), according to the miner: "There is a matter of risk, yes, we cannot hide it. But there we take our measures (...) To minimize or even eliminate the risk during work" (I23).

They mentioned the rigid safety system at work - the golden rule, according to respondents, noncompliance to it caused them to get fired: "They were fired because of that" (E3) and "this person was invited to leave because the rule is: better one person, alive, out there, than a fatality within the company" (I25).

In both periods of the survey, the workers reported pressure to produce and its increase on certain occasions: "There are times when the pressure is enormous. Because we have, we have goals, we have numbers to meet, right? The company has targets to meet, monthly, yearly" (I24), and noted its harmful effects: "if they charge us too much, the risk of an accident increases, and the psychological pressure, fatigue, the mental aspect of the workers will be affected" (I25). A Mariana participant reported: "in a little while everything hurt me, my production fell, I said I was not feeling alright" (I14).

However, workers from both cities did not associate the production requirement with the management style. They consider it satisfactory: "Great! Nothing to complain about" (I25). On the contrary, the Mariana group interviewees reported illnesses, attributed to the process of their activities: "it is an occupational illness, just like the doctor said: this is a chronic illness" (I20). Such report contrasted with the ones of the CMD participants who did not mention them.

The different experiences of the Fundão dam collapse. Regarding the collapse, the participants of the Mariana group actively experienced it. At the time, some were working, others were starting their working day, or preparing to leave their homes. In addition to the impacts generated, victimizing co-workers and family members, there were those who attributed responsibility: "You killed more than thirty people" (I12). The participants also reported feelings of surprise and indignation "it cannot have happened, because I even (...) up until the last minute I spoke like this... a lie, I defended [company name] for any reason. Then, until I tasted it, I was still working for [company name]" (I12).

In addition to these constraints, there were changes in the work routine; some interviewees were designated, without any training, to help victims. The company changed its management policies and adopted measures to reduce costs: paid leave in 2015, followed by collective vacation, and a new period of paid leave in 2016, three periods of contract suspension (between 2016 and 2018), Voluntary Resignation (VRP) and Involuntary Resignation (IRP) Programs. Without the intermediation of managements, who pressured workers to adhere to the VRP, uncertainty and insecurity made interpersonal relationships tense: "we think, right, for a company, will it keep me, or will it keep the other one? (...) another person who (...) is more qualified. Not that we are not, right?" (I13). These actions resulted in a significant increase in unemployment in Mariana, the difficulty of participants returning to the job market, making their projects unfeasible: "Wow, terrible, today, today (...) It is very uncertain" (I14), and it's making people suffer: "Ah, depressed" (I15).

The interviews of the CMD participants took place about three months after the collapse of another dam, the Córrego do Feijão dam in January 2019, in which 272 people died (Assembleia Legislativa do Estado de Minas Gerais, 2019). Due to the severity, among other aspects, the participants referred to that accident: "I was going to get a 16-hour shift (...) So we go to work a little, like this, more shaken, right?" (I25). Another participant expressed "And not to mention that they are our colleagues (...). It could have been with me (...) It is in my work area" (I24). They referred to an accident within the company: "we went through a not so good period last year (...), that occurred (...) in our mining, in the pipeline" (I23).

Effects on work, health, and life. We observed differences

in expectations between the groups of interviewees. The CMD participants, despite being sensitized and expressing solidarity with the victims in both accidents, did not report psychological suffering. They remained focused on their goals and willing to continue their activities, as the interviewee expressed: "I have a good personality, a strong one, thanks to God, so regarding this; it didn't affect me at all" (I25). Another one said: "it didn't stop messing with, with the psychological side of everyone in the mining area" (I24) and another participant summarized "Thank goodness, this company that I'm working for (...). It is already building the dam in the safest way" (I23).

The Mariana group interviewees, however, realized the negative impact of the collapse on their lives, externalizing their suffering. They reported difficulties in reaching their goals due to unemployment, the scarcity of financial resources, conflicts with their families and with themselves, several due to traditional gender orientations, as the participant expressed: "The man is the pillar (...), and now?" (I21). They stated that there are workers with psychic illnesses: "my head got worse" (I17).

Results of the Questionnaires

Table 1 shows the estimated scores and quartiles for each indicator. In common mental disorders, the means are high. In Brazil, a 3.0 score is adopted as the cutoff point (Sá Junior & Wang, 2016) in the population of a primary care center, however, scores above 2.0 are considered an alert for the adoption of preventive strategies (Álvaro, 1992; Banks et al., 1980). Means and scores of 40.5% of participants exceed the alert score and 17 participants exceeded the cut-off point. We found, among the participants of the Mariana group, reports of experiences that can contribute to this elevation.

Table 1
Scores and quartiles in the different mental health indicators (n=163)

Measures / Indicators	Common mental disorders	Self-esteem	Work interference in family	Family interference in work
Minimum	1.00	2.00	1.00	1.00
Maximum	3.67	4.00	6.00	5.00
Mean	2.03	3.18	3.50	2.24
Standard deviation	0,65	0,39	1,27	2,15
Quartiles				
25%	1.50	2.90	2.60	1.40
50%	1.91	3.20	3.80	2.20
75%	2.42	3.40	4.40	3.00

Scores in the RSES indicate moderately high self-esteem. Observing the quartiles, we verified that 50% of the sample exceeded the mean, with one participant scoring maximum points on the scale. We observed that there is a greater tendency for higher scores. Such results corroborate what the interviews expressed about perceiving themselves as individuals with excellent professional qualifications, despite the few job opportunities.

Regarding the WFI, the mean coincides with the midpoint of the scale, with a concentration around it. Since the 50% quartile, the scores are above the sample mean, indicating an increased perception of WFI and 10% are close to the maximum score of the scale, in line with what the interviews related about the impacts of working shifts in the family life. Likewise, the fact that some participants, due to their jobs, live in different cities to their families also corroborated such scores. In the distribution of scores of FWI, the sample mean, as well as the scores of 75% of

the participants, are below the midpoint of the scale, indicating a decreased perception of family interference in work.

We applied cluster analysis to approximate the general mental health settings shared by the sample, based on the measured indicators. We identified five different profiles (Table 2).

Table 2
Mental Health Profiles (N=163)

Mental Health Indicators	Mental Health Profiles				
	I	II	III	IV	V
Common Mental Disorders	2.62	2.46	1.93	1.80	1.65
Self-esteem	3.04	3.12	3.02	3.32	3.32
Work interference in family	5.07	4.68	3.71	3.14	1.66
Family interference in work	3.94	1.93	3.04	1.54	1.51
Participants	18	35	39	36	35

The examination of the referred Table, allowed us to describe the five profiles as follows:

- Profile I (18 participants). These individuals had a conflicting work-family relationship, with the highest mean scores among the profiles of these indicators. In other words, they experience a high degree of difficulty in matching work demands with family members and, at the same time, perceive a moderately high family interference in work. They had the greatest tendency to common mental disorders and, despite they have achieved a moderate score on the self-esteem scale, their mean in this indicator is below the sample.

- Profile II (35 participants). These individuals perceived high WFI, but low FWI (lower than the sample mean and below the midpoint of the scale). The common mental disorders mean is above the alert point and is worrying because it corresponds to 21.5% of the participants. The self-esteem score is moderately high, close to the sample mean.

- Profile III (39 participants). Individuals in this profile perceived the moderate existence of conflict between work and family, presenting both indicators in moderate degrees. They tended to have low scores for common mental disorders, below the midpoint (2.5 of the scale) and the alert point (Álvaro, 1992; Banks et al., 1980). The mean self-esteem score is below the sample mean; however, it remains moderate.

- Profile IV (36 participants). The members of this profile perceived the WFI to the midpoint, but a lesser extent than the previous profiles. They attributed the second lowest score, among the profiles (below the midpoint), to the FWI. The mean score for common mental disorders (the third lowest among profiles) is below the midpoint and the alert point (Álvaro, 1992; Banks et al., 1980). They had a moderately high RSES mean, above the sample mean.

- Profile V (35 participants). These individuals showed moderately high self-esteem, which is combined with the lowest scores for common mental disorders in the sample and little difficulty in matching work demands with family members.

We examined the distribution of participants in the clusters, according to their workplace (Table 3). The percentages suggest a slight tendency towards a predominance of workers from the Mariana group in clusters 1 and 2, however the results of applying the chi-square do not significantly reject the independence between clusters and workplaces ($\chi^2 = 3.19$, $SD = 4$, $p = 0.53$).

We then applied the t-test to compare the scores obtained in each scale in Mariana and CMD and found a significant relationship between the scores of common mental disorders and the place of work ($F = 19.19$, $t = 5.96$, $p \leq .001$), where the Mariana miners showed a greater tendency towards common mental disorders.

Table 3
Distribution of participants per cluster and city of work (N=163)

Cluster	City/place of work	
	Mariana	CMD
I	72.2%	27.8%
II	77.1%	22.9%
III	66.7%	33.3%
IV	61.1%	38.9%
V	60.0%	40.0%
Total	66.9%	33.1%

$\chi^2 = 3.19$; $df = 4$; $p = 0.53$

Discussion

We observe that the living and working conditions of the participants are similar. Such conditions originated in the practice of mining companies (Minayo, 2004). Despite this, the two cities are at the extremes of the mining cycle, which is based on soil contents and measured reserve (quantity of ore in the mine). Ore reduction generates a higher cost for extraction and may encourage companies to migrate their investments to more profitable areas. CMD, whose iron content is 65% and with reserves at the beginning of the mining cycle, is in the initial phase of the process in which the company seeks to assume an expressive role in the city and in society, contributing to improvements in living conditions, such as in health and education, according to interviewees. It seeks to insert itself in the community and to organize local life (Minayo, 2004), encouraging productive specialization and the emergence of political and social dependence, the ore dependence (Coelho, 2018).

In Mariana there is a slowdown in the mining process, also caused by the decrease in the percentage of iron found (currently 45%) and evidenced by the decline in municipal tax collection (Prefeitura Municipal de Mariana, 2019). This situation led to a loss of popular support for the company that owns Fundão and its workers. Despite the demonstrations for the return of the company's activities, some people blamed the participants for the dam collapse and the consequent economic decline in the city. Applying, then, the concept of social position (importance of position in the social structure recognized by others) that we mentioned, considered in the ecological and social causation models in the introduction, we understand that there were losses for the miners in Mariana.

Warr (1987) pointed out that the valued social position is one of the environmental characteristics that influences mental health and the negative effect of its loss. According to Mirowsky and Ross (1989), the social position affects the perception of society and human relations, which is essential for understanding the patterns of malaise in individuals. Ansoleaga and Toro (2010) reported a greater predisposition for the development of depressive symptoms among Chilean miners, in a situation of low social support. In the present research, the participants of the Mariana group showed a greater tendency towards common mental disorders, corroborating the findings of these authors.

Similar corporate management strategies, such as better wages, working conditions, PRS, and indirect wages, contributed to attracting and securing their workforce, reported by the individuals of the CMD group as their first opportunity to acquire goods. The incentives for continuing education of workers raised their educational level, contributed to the efficiency and productivity of companies and the creation of an image of excellence by miners, corroborating a previous study (Minayo, 2004), also contributing

to the moderately high self-esteem of the sample, observed in all clusters. It is higher than among Spanish miners (Vázquez Morejón, García-Boveda, & Jiménez, 2004), similar to the Chilean sample of Rojas-Barahona, Zegers, and Förster (2009), showing a high trend regarding to the study with 53 nations, and below the Argentine population (Góngora & Casullo, 2009).

We believe that a moderately high self-esteem is an aspect that can favor the search for better working and living conditions and help the participants of the Mariana group to reorganize their lives. However, the return to the job market, according to reports, has been in lower working conditions and wages, with less training requirements. In terms of the ecological model (Warr, 1987) there is an impoverishment of the social environment in terms of the opportunity to use skills, the realization of external goals, and economic availability. These aspects can result in mental health damage. In the case of the participants, it can represent suffering, as it affronts the miners' self-esteem, partly built on their professional activities, as we have already commented.

We also observed that there were no reports of illnesses related to the work process by individuals of the CMD group. We considered that it can be related to the difference in the time of activity of the mining companies, which have operated for 43 years in Mariana and 12 years in CMD (Dias & Oliveira, 2018; Rosa, 2019). This may imply both less exposure to risks and the use of new technologies, a fact that seems to support this belief among the CMD workers, of greater security in the mining process, especially of the tailings dam. We also consider the possibility of constraints in expressing illnesses at work, due to a culture of toxic masculinity, based on hard work to acquire goods, and the lack of expression of emotional stress/tension or mental health problems detected in this type of activity (Kotera et al., 2019; Seaton et al., 2019).

The adversities in the work process reported by the CMD group refer to working in shifts, a possible cause of work interference in the family (Barbosa & Borges, 2011) as well as the fact that several participants live in a different city from their families, which can accentuate the work-family conflict.

Regarding the collapse and its consequences, the interviewees of the Mariana group reported pressure to adhere to the termination programs, as well as the worsening of interrelationships. Both aspects constitute a risk to mental health (C. Fernandes & Pereira, 2016; Palma Contreras et al., 2018; Rabelo et al., 2018; Warr, 1987). Likewise, reports of difficulties in achieving their goals due to unemployment and/or scarcity of financial resources, according to Llosa-Fernandes et al. (2018), increases the risk of depression and anxiety. We also observed an increase in family conflicts due to the difficulty in providing the same previous living conditions. Among the participants, several expressed guilt, signaling traditional gender role orientations, which Eby, Maher, and Butts (2010) pointed out as responsible for accentuating the work-family conflict. Such situations, in addition to the already mentioned losses of social support, generate stressful psychosocial conditions, which can negatively contribute to mental health (Marchand & Durand, 2011).

Although the reports of the CMD interviewees denote that the ruptures of the dams caused apprehensions regarding the exercise of their activities and demonstrate empathy for colleagues who were physically victimized by the tailings, they showed fewer tendency to common mental disorders.

Therefore, we can observe that, from the Fundão dam collapse, the group of workers from Mariana experienced significant losses, showing unfavorable environmental conditions considering Warr's model (1987).

Such losses also mean marked changes in social position that,

according to Mirowsky and Ross (1989), can generate impotence and social isolation (types of alienation), accentuate inequality, generating the feeling of injustice, which contribute to the increased feelings of malaise (depression and anxiety). For these authors, the conditions that produce certain events and/or their consequences, as well as the active answers to them, are largely responsible for the psychological impact of the event, which we understand to have occurred to the participants of the Mariana group.

Closing Remarks

We reached the objective of this study, by empirically evidencing that the working and living conditions, as well as the mental health, of mining workers, who were working when the dam broke in Mariana, differ from those miners working in another mining location, and are unfavorable considering the ecological, social causation, and biopsychosocial models that explain the relationship between mental health and work.

We emphasize that the accentuated changes in social position contributed to intensifying feelings of malaise, depression, and anxiety (Mirowsky & Ross, 1989; Warr, 1987).

A limitation of the present study resulted from the choice, in the field activities, of two groups with people who are overly sensitive to the collapses of tailings dams. This fact led us to decide not to use structured questionnaires that cover living and working conditions, as we believe that an extensive protocol would be impossible to apply. Such aspects which, in the models mentioned in the introduction, are antecedent components, were explored exclusively in the interviews. Although we report statements by interviewees of the Mariana group that refer to the nexus between such aspects and mental health, we did not directly explore them, since it was not the objective of this study. Researchers who can build other means of access to participants can explore this link.

Additionally, this obstacle has grown in CMD, preventing us from reaching a closer number of participants to the Mariana group. This difficulty, perhaps, may have contributed to hiding differences in the distribution of clusters. With more participants in the CDM group, we would be able to go deeper into some statistical analysis. The situation also reflected the influence of living and working conditions in mining, as the CDM field activity took place in April 2019, about three months after the Córrego de Feijão dam collapse that killed 272 people (ALEMG, 2019), and workers were afraid to participate, many because of possible retaliation by their company.

Finally, we note that we must understand the results in order to focus on the need to develop protective and follow-up actions for workers involved in large-scale events/accidents, even if they have not been physically affected, as the psychosocial effects are numerous.

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Information about the authors:**Georgina Maria Véras Motta¹**

Av. Getúlio Vargas, 1244, apto 201, B. Funcionários
30112-021 Belo Horizonte, MG, Brasil.
E-mail: georginavmotta@gmail.com

Livia de Oliveira Borges²

E-mail: liviadeoliveira@gmail.com

¹ Doutoranda pelo Programa de Pós-graduação em Psicologia da UFMG.

² Professora titular aposentada atuando voluntariamente no Programa de Pós-graduação em Psicologia da UFMG e Bolsista de Produtividade em Pesquisa pelo CNPq.