Centro Unversitário Santo Agostinho

revistafsa

www4.fsanet.com.br/revista
Rev. FSA, Teresina, v. 18, n. 01, art. 4, p. 74-99, jan. 2021
ISSN Impresso: 1806-6356 ISSN Eletrônico: 2317-2983
http://dx.doi.org/10.12819/2020.18.01.4

Workplace Accidents as a Consequence of Human Error: An Empirical Study in a Gold Mine

Os Acidentes de Trabalho como Consequência dos Erros Humanos: Um Estudo de Caso em uma Mina de Ouro no Brasil

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Editor-Chefe: Dr. Tonny Kerley de Alencar Rodrigues

Artigo recebido em 02/11/2020. Última versão recebida em 16/11/2020. Aprovado em 17/11/2020.

Avaliado pelo sistema Triple Review: a) Desk Review pelo Editor-Chefe; e b) Double Blind Review (avaliação cega por dois avaliadores da área).

Revisão: Gramatical, Normativa e de Formatação

ABSTRACT

In a context where high rates of accidents in the mining industry still occur, this study aims to evaluate if life events of employees of a large mining company in Brazil can cause human errors. Through the technique of modeling structural equations, is measured the causal relationship between life events, capacity for overcoming, stress, psychological function, physiological function, and human error. This based on the assumption that life events can influence these variables, which in turn can generate human error and cause damages to the workers. All the hypotheses of this relation were validated in a gold mining company with more than 600 employees. The results show that the life event is interconnected with human error and that the stress is an agent that influences this process. Furthermore, the descriptive statistics allowed to identify in which groups, selected from sociodemographic variables, there are higher possibilities of human error. The results have theoretical and practical implications and suggest measures that may contribute to reducing psychological and physiological dysfunctions to avoid workplace failures.

Keywords: Workplace accidents. Human Error. Mining. Structural Equations.

RESUMO

Em um contexto em que ainda ocorrem altas taxas de acidentes no setor de mineração, este estudo tem como objetivo avaliar se os eventos de vida de funcionários de uma grande empresa de mineração no Brasil podem causar erros humanos. Através da técnica de modelagem de equações estruturais, é medida a relação causal entre eventos da vida, capacidade de superação, estresse, função psicológica, função fisiológica e erro humano. Isso se baseia no pressuposto de que os eventos da vida podem influenciar essas variáveis, que por sua vez podem gerar erros humanos e causar danos aos trabalhadores. Todas as hipóteses dessa relação foram validadas em uma empresa de mineração de ouro com mais de 600 funcionários. Os resultados mostram que o evento da vida está interligado ao erro humano e que o estresse é um agente que influencia esse processo. Além disso, as estatísticas descritivas permitiram identificar em quais grupos, selecionados a partir de variáveis sociodemográficas, há maiores possibilidades de erro humano. Os resultados têm implicações teóricas e práticas e sugerem medidas que podem contribuir para reduzir disfunções psicológicas e fisiológicas para evitar falhas no local de trabalho.

Palavras chaves: Acidentes de Trabalho. Erro Humano. Mineração. Equações Estruturais.

1 INTRODUCTION

The search for measures to eliminate occupational accidents is a priority of almost all organizations and has become a worldwide concern due to many accidents and deaths that have occurred throughout history. Some sectors are distinguished by the degree of dangerousness and insalubrity involved in their work processes, and, between them, mining stands out. Despite the importance of this sector as an indispensable source of raw material for society, mineral activity carries with it major risks to the health and safety, environment and welfare of the community (Amoah & Stemn, 2018). Besides, injury and fatality rates in this harsh work environment are very high compared to other industries (Kumar et al., 2016).

In the Brazilian scenario, mining activity is classified as risk grade 4, considered as the highest by the *Labour and Employment Ministry (MTE),* constituting one of the most dangerous work processes (Costa & Rezende, 2012). Although the improvements occurred in recent years due to work accidents prevention, the records of these occurrences in the mining industry remain a concern. According to the Special Secretariat of Welfare and Labor (Secretaria Especial de Previdência e Trabalho, 2016), in 2016 were registered 3,823 work accidents with an average of 1,736 accidents per 100,000 workers. In comparison, in the same period, there were 365 accidents per 100,000 employees in the Australian mining industry (Department of Mines, Industry Regulation and Safety, 2016).

Numerous causes culminate accidents in the mining workplace, and human error is one of the most important. To Kumar *et al.,* (2016), human error plays a crucial role in accidents and Rushworth et al., (1999), verified that almost 85% of all mining accidents could be attributed to at least one human error. The error occurs when a planned sequence of mental or physical activities fails to achieve the desired result (Reason, 1990).

In recent years, several studies have been carried out aiming to find the fundamentals behind human errors. Most of them focused on analyzing various factors related to human error such as credibility, control model, mechanism, and their frequency (Li & Yi-Qun, 2001; Liu et al., 2007). These analyses did not consider cognitive psychology as a support to understand the human error (Liao et al., 2006; Liu & Zheng, 2010), lacking the analysis of external factors such as life events (Zhang, 2014).

Life events are events that often easily arouse emotional disorders, which usually can involving danger and fundamental changes in health (Krenek & Maisto, 2013). In addition to the pressures typical of an organization and the specific characteristics of the mining environment, miners are also subject to life events of different kinds, which are often

unpredictable and universal to anyone. When miners face such circumstances, their psychological balance is disturbed, and they may suffer from emotional fluctuations and psychological pressure. From the reality of the high rates of work-related accidents that persist in the analyzed sector, the research problem proposed is: What is the impact of life events on human errors in the Brazilian mining environment?

This research aims to measure the causal relationship between life events, capacity for overcoming, psychological stress, psychological and physiological function, and human errors. It will be done using the statistical technique of modeling structural equations, based on the assumption that life events will influence the other variables, which may generate human error, causing damage to workers. Besides, the descriptive statistics will be used to identify in which categories of sociodemographic variables analyzed there is a higher possibility of human error.

Studies about occupational accidents are essential since involves the health of workers, namely, health and society (Simonelli et al., 2016). Moreover, many of these occurrences can be avoided, because of the numerous factors that are capable of triggering work, accidents are already present before the accident effectively occur (Santana et al., 2006; Binder & Almeida, 2013). Thus, it is necessary for more researches involving safety hazards and issues related to human performance (Tripathy & Ala, 2018).

There are several limitations in the current literature on life events (Paluch et al., 2018) and its relation to human error is still little explored in studies on health and safety at work. In terms of contribution to the literature, this study aims to fill the existing gap in work safety studies that address the effect of cognitive psychology on accidents. The majority use preventive measures of operational and environmental nature, disregarding the influence that the personal life of the employee can exercise in its operational and cognitive functions. In this sense, it seeks to broaden the discussion about the life events theory and their influence on the lives of employees who work in a dangerous and often unhealthy sector.

As practical contribution, this study suggests measures that may reducing psychological and physiological dysfunctions to avoid workplace failures, besides presents evidence that helps the improvement of existing legislation on safety and quality of life at work.

In order to find an answer to the problem and the specified objectives, this study is organized as follows: Section 2 has the theoretical fundaments on the life events; the methodology used are described in Section 3; in Section 4 are presented the results and the discussion; and Section 5 specifies the conclusions of the paper.

2 THEORETICAL FOUNDATION AND HYPOTHESES DEVELOPMENT

The issues of safety are of utmost importance for the proper functioning of the mining companies (Amoah & Stemn, 2018). Although the organizations invest in training and policies orientated to work safety and occupational health programs, the risk of accidents in certain environments is always eminent. And increasingly, industrial accidents involve human factors, (Skalle et al., 2014; König et al., 2018) which highlights the importance of understanding the errors reason.

The causes of human failures are diverse, and thus the operations that involve contact with individuals must be seen as complex processes. The errors can be related to several aspects such as environmental interferences, organizational and technical factors or even related to the personal life of the employee (Rong et al., 2016; Tripathy & Ala, 2018).

In this way, the theory of life events proposed by the American psychologists Holmes and Rahe (1967) elucidates that certain situations cause changes in human behavior, making the necessary some adjustments for us to deal with those events that we experience at some point. In the literature, the understanding that life events are facts that bring about changes in our life is the predominant (Krenek &Maisto, 2013).

The events can be predictable or not, and these experiences can be classified according to Mcquaid et al. (1992) in terms of magnitude - major or minor events, importance - acute or chronic, the degree of difficulty, and running time (Zhang, 2014). For example, the birth of the child is considered an important event, by and large, desirable and expected during a given period. On the other hand, it may bring some degree of financial difficulty and adaptation to parents.

Already the death of some family member possibly will have an opposite effect for many people can suffer mental and physical consequences during a certain period. According to Holmes and Rahe (1967) this "collateral" effect on certain life events causes an imbalance in mind and body, for instance, situations typical of adulthood such as employment changes, beginning or ending of relationships, financial issues, illnesses are examples of life events (Paluch et al., 2018).

The research of Burns and Machin (2013) has brought evidence that life events are most strongly associated with malaise and results from Lu et al. (2013) suggest that there is a relation between life events and the internalization of problems, since when experiencing adverse situations in life can development of cognitive vulnerabilities. In this sense, Leggett et

al. (2015) elucidate that these events can cause negative feelings in people and may even harm the individual life.

Besides, life events can cause high-stress levels. Stress is a state of advanced homeostasis, in which individuals react behaviourally, physiologically and psychologically, in an attempt to recover homeostasis (Paluch et al., 2018). Krenek and Maisto (2013) suggest that stress is related to the conceptual definition of life events and, in addition, these imbalances have been associated with higher risks of physical and mental illness (König et al., 2018).

However, individuals respond differently to life's adverse events. Some people are more susceptible to the effects of daily annoyances, while others are not as affected as there are different levels of stress sensitivity (Qiao et al., 2013). While some people present a chronic stressful life cycle, others are strong enough to overcome adversity and even make positive changes in response to a situation (Park et al., 1996; Mcmillen et al., 1997).

The coping style of a situation helps people deal with the stresses of everyday life both emotionally and cognitively and can mediate the relationship between stressful life events (Li et al., 2010; Tang et al., 2014). Thus, as higher the coping capacity and overcoming of life events, the fewer people will be susceptible to stress. On the other hand, if the ability of individuals to cope with certain life events is null or insufficient and the emergence of stress is inevitable, physical and mental health to some degree will be affected in some way.

From the studies by Holmes and Rahe (1967) about the impacts of life events and their effects on health, many research began to be taken has sought to investigate the relation between the occurrence of life events and psychological and physical health (Paykel, 2001).

Certain bad life events were related to being associated with depression and anxiety (Eley & Stevenson, 2000; Lu et al., 2013) and they may represent a psychological vulnerability (Chorpita & Barlow, 1998; Barlow, 2000; Bolger & Patterson, 2001; Lu et al., 2013). The examples of arising stressing psychological dysfunctions are the loss of concentration, lack of will to do things, desire to work among other symptoms.

Moreover, the physiological function is also affected in response to stress caused by some life event. Life events are associated with physical and mental health (Burns & Machin, 2013; König et al., 2018), and there were proposed several models to analyze the relationship between adverse life events and physiological symptoms (Radziej et al., 2015). The majority suggests that the continuous effects are increased processing of disordered information, nervousness, changes in perception mechanisms, memories lapses, difficulty in ordering thoughts and reflexes to react under the brain command.

The studies by Leggett et al. (2015) suggest that life events and sleep disorders were associated with depressive symptoms and according to Qiao et al. (2013), an individual predisposition to experience, adverse life events may cause vulnerable to some psychopathological and physical illnesses.

In this way, it can be inferred that the stress reaction to the particular situation of the personal life will interfere in the psychological and physiological mechanisms, which in turn, may influence the occurrence of human errors. This argument corroborates with the studies of Lu et al. (2013) who concluded that life events are significantly related to cognitive errors. Based on the above, the following hypotheses will be analyzed:

H1: Life events have a significant influence on the stress of miner;

H2: The overcoming has a significant influence of the inverse ratio on the stress of miner;

H3: Stress has a significant influence on the psychological function of the miner;

H4: Stress has a significant influence on the direct ratio on the physiological function of the miner;

H5: Stress has a significant influence on the direct reason for the human errors of the miner;

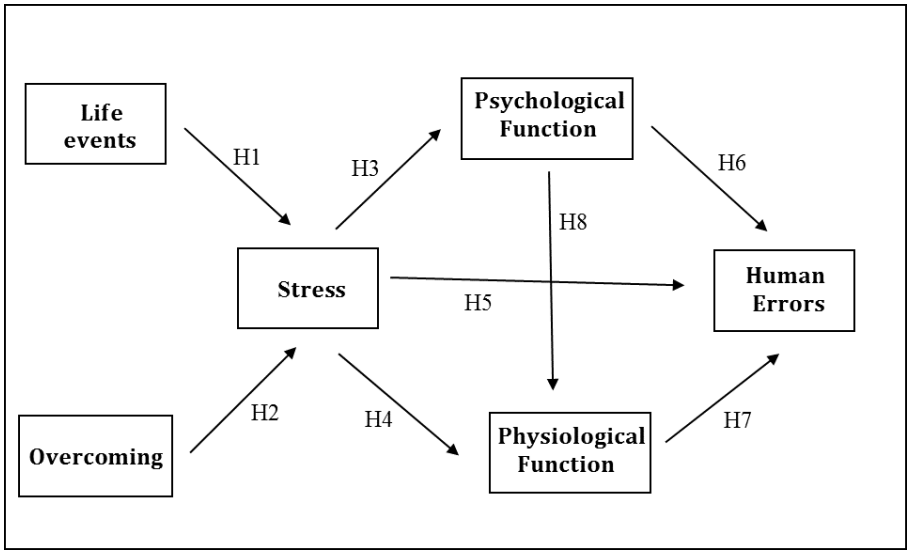
H6: The psychological function has a significant influence on the human errors of the miner;

H7: The physiological function has a significant influence on the human errors of the miner;

H8: The psychological function has a significant influence on the physiological function of the miner.

The model to be tested is shown in Figure 1 and reflects the proposition of the hypotheses presented above. Each hypothesis composes a construct represented by a latent variable, which will affect another variable by a cause and effect relation. The six constructs together form the model.

Fig. 1 – Model (based on Zhang, 2014).



The constructs are composed of observed variables identified in the literature with the objective of representing in a more complete form possible the latent variable. For example, the observed variables that describe the life events are three: Importance, difficulty degree and duration time. These classifications will be discussed in the front for further understanding.

3 METHOD

This research has an applied nature since it seeks to generate knowledge for the practical application and to solve problems from established objectives. The approach is quantitative once there are hypotheses to be tested and statistical methods that are used for data processing. In terms of general objective, it is classified as a descriptive research, because the phenomenon characteristics will be described from a theoretical field for better comprehension.

In addition, a case study was realized analyzing the processes and the relationships between them to understand it in depth. Yin (2001) argues that one of the main objectives of the case study is to explain causal links in real-life interventions. To Gil (2002), the possibility of understanding a phenomenon in a broad and detailed way is a task practically impossible by other methods.

The present study was conducted in the largest gold mine in Brazil (Revista Minérios & Minerales, 2016). The reason for this choice is the size of the company and, consequently, the high number of employees, besides the importance of the ore mined. The gold is part of the precious metals class with highest rates of industrial accidents in Brazil when compared to other metallic minerals classes. According to the Brazilian Social Security in 2016, the mortality rate of this group was 23.17 (in 100,000), the lethality rate was 10.91 (in 1,000), and the rate of work accidents between16 to 34 years was 61.92 (in 100).

The sample size was estimated at 119, and this number was determined using the G * Power software. The calculation is based on the formulated model construct that receives the largest arrows number or that has the most significant predictor's numbers. The data collection occurred by locally applying 630 questionnaires between November and December 2018, which 611 (97%) were considered valid. This data was deemed accurate based on the questionnaires exclusion that contained more than 10 percent of null replies. Thus, it was obtained almost five times the recommended sample by G * Power. Employees from twenty-two sectors of the company filled the questionnaires with the purpose of increasing the observed variance and allowing a strong comprehension of the reality. The anonymity of the respondents was guaranteed and the bias associated with those who did not wish to respond for reasons of confidentiality was reduced (Bialaszewski & Giallourakis, 1985).

The elaboration of the data collection instrument followed the guidelines of the study of Zhang (2014), and after its translation, academic researchers familiar with the subject evaluated the accordance of the items. Thus, the questionnaire was validated by six professionals from different areas like psychology, work safety engineering, among others, and the research was reviewed based on their comments. After that, they were applied to approximately forty students to adapt it in language terms, comprehension, clarity, and content.

The questionnaire has nomological validity and included sociodemographic data consisting of six questions, and six variables (Salary Range, Company Time, Age Range, Marital Status, Number of Children, and Gender). It also has a section composed by 22 questions regarding the observed variables, which in turn represent the six model latent variables. Table 1 summarizes all the variables considered in this study, which provided the basis for the questionnaire formulation. Previous studies confirmed the nomological validity by testing the relationship between the constructs.

Table 1 – Model variables used in the questionnaire preparation (based on Zhang, 2014).

Latent Variable	Variable Observed	Latent Variable	Variable Observed
Life events (LE)	Importance (L_1) Difficulty level (L2) Duration time (L3)	Psychological Function (PCF)	Attention (PC_1) The desire (PC_2) Consciousness (PC_3) The desire for work (PC_4)
Overcoming (O)	Ability to overcome (O_1) Individual adjustment (O2) Psychological recovery (O3)	Physiological Function (PSF)	Perception (PS_1) Memory (PS2) Thought (PS3) Action (PS4)
Stress (S)	Emotional disorder (S_1) Thought disorder (S_2) Physiological disturbance (S_3) Psychological nervousness (X_4)	Human Errors (HE)	Perception failure (H_1) Judgment failure (H2) The operation failed (H3) Human error frequency (H4)

The technique for data analysis used was the modeling structural equations to evaluate the interrelated dependency relations through the software SmartPLS. After that, descriptive statistics were performed using SPSS software to organize and present the data in an objective and clear way. As a result, the human error possibility was analyzed with each sociodemographic variable.

4 RESULTS AND DISCUSSION

In order to ensure the reliability of the construct, the internal consistency of the questionnaire responses was assessed using Cronbach's alpha and composite reliability, as can be seen in Table 2.

The values of this first indicator for each construct are above 0.6 and are satisfactory as recommended by Churchill (1979). The composite reliability that is a unit of analysis more rigorous than the Cronbach's alpha for taking into account different external loads of the indicator variables had values above 0.7. Thus, the highest level of reliability possible was achieved as suggested by Hair et al., (2005) indicating that all scales used in this study were reliable.

Then, the algorithm obtained the results of the measurement models, in order to relate the constructs and their indicators. The R^2 of 0.562 of the human errors indicates that all variables (life events, overcoming, stress, psychological function, and physiological function) together explain 56.2% of the variance of human errors. In general, values above 0.2 are significant.

The values of the external loads were calculated in order to ascertain the reliability of the variables. As can be seen in Table 2, the external load values of all the indicators were above 0.7 indicating that the latent variable explains more than 70% of the variance of each indicator. This means that the associated indicators have a lot in common causing it to be captured by the construct and justifying the fact that the indicators are reflexive.

Then, the discriminant validity evaluated to what extent a construct is truly distinct from the others, that is, each construct considered in the model was the only one to capture the phenomenon analyzed. The measure of discriminant validity used was the criterion of Fornell-Larcker, whose square root of its value corresponds to the mean-variance extracted (AVE). The reading in Table 2 also allows verifying that the values exceed the reference value of 0.5 (Fornell & Larcker, 1981), showing satisfactory reliability and the existence of convergent validity of the mean-variance.

Table 2 – Measurement model

Latent Variable	Composite Reliability	Outer Loadings	Cronbach's alpha	Average Variance Extracted (AVE)	Variance explanation (R^2)
Life Events (LE)	0.831	E1 = 0.748 E2= 0.836 E3= 0.778	0.695	0.622	___
Overcoming	0.854	S1= 0.760	0.744	0,661	___

(O)		S2=0.827 S3=0.849			
Stress (S)	0.801	X1= 0.755 X2 =0.706 X3=0.634 X4=0.734	0.669	0.502	0.233
Psychological Function (PcF)	0.866	P1=0.745 P2=0.824 P3=0.774 P4=0.797	0.793	0.617	0.303
Physiological Function (PsF)	0.904	F1=0.809 F2=0.832 F3=0.852 F4=0.858	0.858	0.702	0.470
Human Errors (HE)	0.881	Y1= 0.836 Y2=0.868 Y3=0.828 Y4=0.682	0.818	0.651	0.562

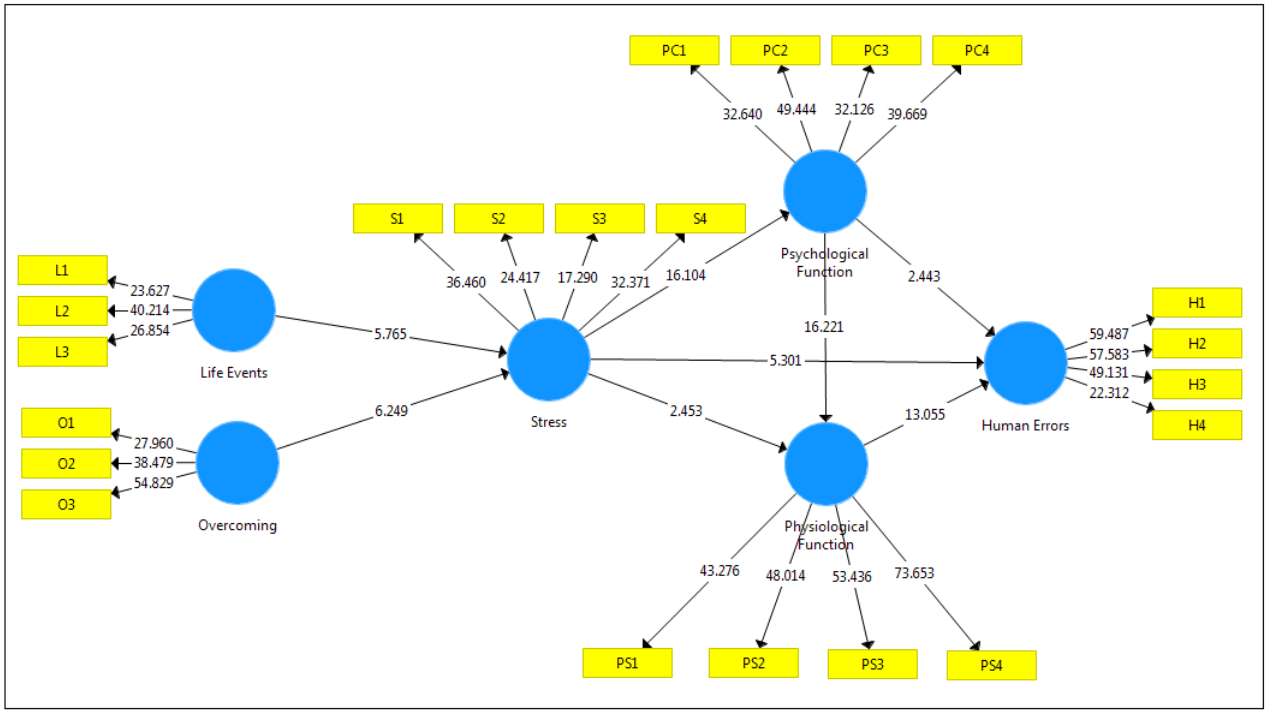
To test the hypotheses, the estimation process was carried out in the modeling of paths by means of the Bootstrapping calculation. The generated report gives the values of the "t" test and the literature indicates that values above 1.96 (significance level of 5%) are sufficient to affirm that the correlations and the regression coefficients are significant, and therefore validate the hypotheses. As can be seen in Table 3 all hypotheses were supported once they reached the level of significance required. The Figure 2 shows the construct with all hypotheses tested and their interrelationships.

Table 3 – Hypothesis test results

Hypotheses	Path	T value
1	LE → S	5.765
2	O → S	6.249
3	S → PCF	16.104

4	S → PSF	2.453
5	S → HE	5.301
6	PCF → HE	2.443
7	PSF → HE	13.005
8	PCF → PSF	16.221

Fig. 2 – Model path diagram



The following will discuss the differences and similarities between the findings of the Brazilian and Chinese case. In the face of the different context between Brazil and China, such as the workload, cultural differences, and the fact that the original model was applied in a coal mining and here is used in a gold mine, this study looked to understand if the variables (Table 1) could influence the validity of the hypotheses initially formulated by Zhang (2014).

The relationship between stress and human error in various circumstances is well known, especially in work settings (Lu et al., 2013, Cohen et al., 2016). Despite this, in the Chinese study, stress did not influence human errors, according to hypothesis 5, while in Brazil, yes. One of the justifications for the validation of this hypothesis in the present study may be the fact that Brazilians are one of the most stressed people in the world. According to

the *International Stress Management Association (ISMA)* survey, Brazilians rank second in relation to people with the highest level of stress when compared to nine countries in the world (Barreto, 2015).

In this aspect, in the Chinese context, the relations of exchange between employees and supervisors tend to be more emphasized due to the importance of social relations in this culture (Wang & Yi, 2011). In addition, they are also linked to Chinese culture, the popular use of herbal medicines in this country is able to reduce stress, anxiety and improve quality of life (Kurebayashi et al., 2016).

On the other hand, as in Zhang's study (2014), the hypothesis 1, that life events influence on the miner's stress was validated according to studies carried out linking life events with the internalization of problems (Lu et al. , 2013) and directly with stress (Krenek & Maisto, 2013). Likewise, the hypothesis 2 what refers the capacity to overcome be inversely proportional to the miner's stress was also supported by statistical tests, confirming the findings of Li et al. (2010) and Tang et al. (2014) that the ability to overcome life events helps to inhibit or even reduce stress levels.

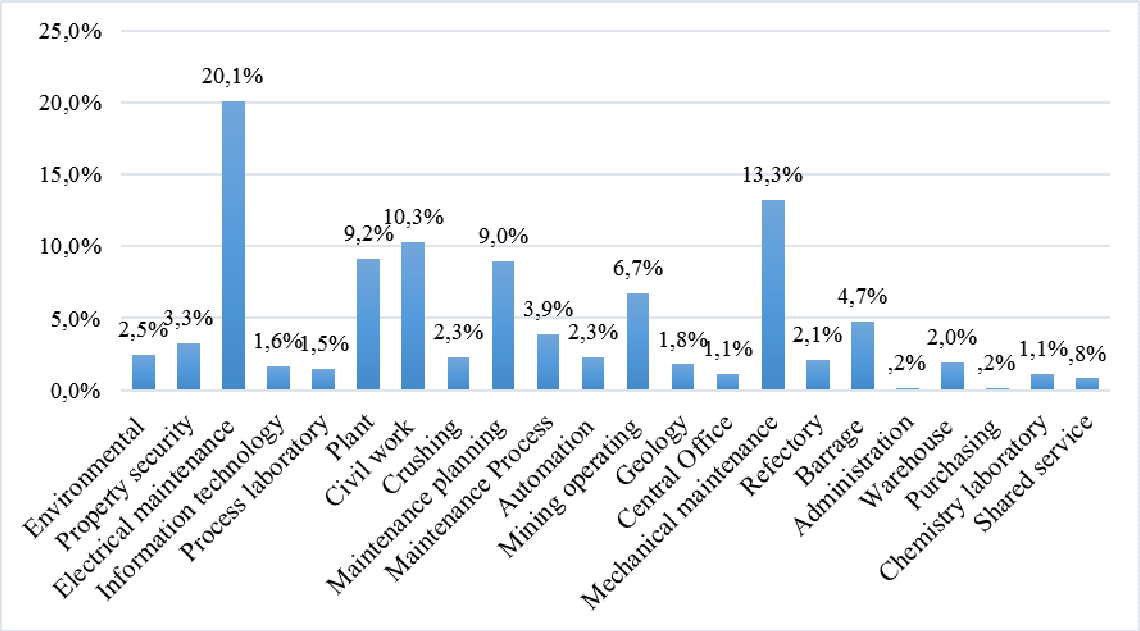
Hypotheses 3 and 4 defended the influence of stress on the psychological (Janis, 1958; Vinokur & Selzer, 1975) and physiological (Cohen et al., 1995; Brosschot et al., 2006) functions of the miner were shown true. This proves the premise that the miner will suffer physiological and psychological imbalances when subjected to certain levels of stress. This finding is very worrying once that part of the mining accidents can be attributed to stress (Hongxia et al., 2014).

In addition, the hypothesis 7, which had the premise of the influence of physiological function on human errors, proved true when considering the various physiological symptoms reported by Radziej et al. (2015), which can create the conditions that cause accidents at work. Similarly, the confirmation of hypothesis 8 which affirmed that psychological function interferes with physiological function (Gellhorn, 1953) was also validated and the relation of such functions to stress has already been reported in the literature (Gellhorn, 1953; Araldi-Favassa et al., 2005).

In the analyzed sample, descriptive statistics showed that 20% of interviewed employees "agree" or "strongly agree" that when they are stressed they have a lack of perception; 18.5% "agree" or "strongly agree" that when they are stressed they have a lack of judgment and of operation, and that 29.8% of employees "agree" or "strongly agree" that when they are stressed they are more likely to commit errors.

It was also possible to identify in which contexts the company's employees have a greater chance of occurrence of a human error, and consequently, of work accidents. The data in Figure 3 shows by means of the "% in the possibility of human error" in which sectors there is a greater possibility of occurrence of human error. It can be observed that the sectors where such chances are higher than 10% in ascending order are: Civil Works (10.3%); Mechanical Maintenance (13.3%) and Electrical Maintenance (20,1%).

Fig. 3 – Possibilities of human error according to the sector



From Table 4, it can be observed that employees who have their incomes between 1 and 3 wages are the ones that are more likely to commit human errors, corresponding to 69.4% of the total, followed by those with have incomes above 3 up to 6 wages (23.9%). This relationship may be a reflection of the low level of education of these employees, which may lead them to the misunderstanding of work orders, difficulty in drawing up alternative strategies in the face of a risk situation, incorrect interpretation of some instruction, etc.

The data also showed that the greater the time of experience in the company, the lower the chances of human errors being committed in the analyzed case. Employees with up to 3 years of company, have a 49.1% possibility of human error, followed by 20.1% for those who are older than 3 up to 6 years; 13.8% for those over 6 up to 9 years; 9.7% for those over 9 up to 12 years; and 7.2% for employees who have been in the company for more than 12 years.

Next, we have a group that is above 32 to 39 years old, with 23.6%. This relation between age and the possibility of human error did not have a direct proportion between aging and the occurrence of errors. In addition, the data in Table 4 show that the possibility of human error is higher for those employees who are married (60.1%), followed by those who are single (30.45%).

In relation to the number of children of the employees who composed the sample, it was verified that those who do not have children are more likely to commit human errors (36.4%), followed by those who have a child (27.8%) and of those who have two children (23.6%). The increase in the number of children is inversely proportional to the chances of human errors in the analyzed case. At last, the findings show that the chances of human errors among male employees are significantly higher (85.9%) when compared to female sex workers.

Table 4 – Possibilities of human error in relation to sociodemographic variables

		Strongly disagree (% of Total)	Disagree (% of Total)	I do not agree or disagree (% of Total)	I agree (% of Total)	I totally (% of Total)	Total
Wage Range	Between 1 and 3 wages	14,9%	19,0%	15,0%	12,5%	8,0%	69,4%
	Above 3 up to 6 wages	5,0%	6,5%	4,8%	5,8%	1,7%	23,9%
	Above 6 up to 9 wages	1,2%	,8%	1,8%	,7%	0,0%	4,5%
	Above 9 up to 12 wages	,3%	,2%	,2%	,8%	0,0%	1,5%
	Above 12 wages	0,0%	,3%	,3%	0,0%	0,0%	,7%
Company Time	Up to 3 years	11,2%	10,4%	12,5%	8,7%	6,3%	49,1%
	Above 3 up to 6 years	4,0%	8,2%	3,1%	4,0%	,8%	20,1%
	Above 6 up	1,0%	3,5%	3,6%	4,0%	1,8%	13,8%

	to 9 years						
	Above 9 up to 12 years	2,1%	2,5%	1,8%	2,6%	,7%	9,7%
	Above 12 years	2,5%	2,0%	1,6%	,8%	,3%	7,2%
Age Range	Between 18 and 25 years old	4,4%	4,3%	5,3%	3,3%	2,0%	19,2%
	Above 25 up to 32 years old	6,9%	8,4%	6,4%	7,1%	3,8%	32,5%
	Above 32 up to 39 years old	5,9%	6,2%	5,6%	4,6%	1,3%	23,6%
	Above 39 up to 46 years old	2,1%	4,1%	2,6%	2,0%	2,0%	12,8%
	Above 46 years old	1,5%	3,6%	3,0%	3,0%	,8%	11,8%
Marital Status	Single	6,6%	7,3%	6,4%	6,8%	3,3%	30,4%
	Married	13,2%	15,8%	13,0%	12,0%	5,9%	60,1%
	Widower	0,0%	0,0%	,2%	0,0%	0,0%	,2%
	Separated/ divorced	,2%	,7%	1,7%	,5%	,5%	3,5%
	Other	,8%	2,8%	1,7%	,5%	,2%	5,9%
Number of children	0	6,8%	8,8%	8,8%	8,8%	3,3%	36,4%
	1	6,1%	6,4%	6,9%	5,5%	2,8%	27,8%
	2	5,3%	6,3%	4,5%	5,0%	2,6%	23,6%
	3	1,7%	4,1%	1,5%	,3%	,7%	8,3%
	Above 3 children	1,0%	1,0%	1,2%	,5%	,3%	4,0%
Gender	Feminine	2,9%	3,2%	2,3%	3,9%	1,3%	13,6%
	Male	17,8%	23,2%	20,0%	16,4%	8,6%	85,9%

The understanding that the shorter the time of experience in the company, the greater the chance of occurrence of error converges with the findings of Wenwen et al. (2011), where it was evidenced that workers with less time, necessarily have less experience in that specific function of company. As a consequence, they are more susceptible to human errors due to the incomprehension of security rules or even forgetfulness of them. Others factors are the psychological insecurity to execute certain functions or the need to want show competence, which often leads to the transgression of safety rules.

Furthermore, the evidence from the result show that the chances of errors are higher among employees who are married and those who do not have children. This finding differs from the study by Szurlan, Gleriano & Justi (2015) and although these authors also agree that these variables influence the employee's professional activities, in their findings, they concluded that married professionals with children, because they have more responsibilities, they are more attentive and careful in the workplace, which reduces the tendency to human error.

In relation to the finding that the chances of human errors among male employees are significantly higher than in females it may be because females can create strategies for coping with stress (APA, 2019) and consecutively avoid mistakes, as well as other attributes that are characteristic of women, such as high concentration, discipline with respect to rules and prudence.

5 FINAL CONSIDERATIONS

This study was carried out in a gold mine in Brazil and through the modeling technique of structural equations was possible measure the causal relationship between life events and human errors. The results revealed that the life event is interconnected to human errors in the analyzed work environment and that stress is an agent that influences this process.

All the hypotheses raised were validated from the statistical tests. The initial premise that the life events of the employees will generate the stress that will be inversely proportional to the capacity of overcoming each one was validated. The stress, in turn, will cause an imbalance in the psychological and physiological functions, and also the psychological function will influence the physiological function. Such imbalances will foster the human

error. These findings reinforce the importance of safety management into account take external causes that may influence the behavior of its employees and shows the need for strategies that may mitigate the imbalance of these functions.

Besides that, by means of descriptive statistics, it was possible to identify in which contexts in which the employees of the company are inserted there is a greater chance of occurrence of the human error, and consequently, of work accidents. Regarding the gender of the employee, it was observed that the chances of human errors among male employees are significantly higher (85.9%) when compared to the female sex.

The sectors of the company where human error is most likely to occur are "Civil Works", "Mechanical Maintenance" and "Electrical Maintenance". It was also found that employees with lower salaries are more likely to make mistakes. In addition, the results indicated that the longer the experience in the company, the lower the chances of human errors being committed, but in relation to age, there was no direct relationship between aging and occurrence of errors.

Regarding the marital status of employees, it was observed that the possibility of human error is greater for those who are married followed by those who are single. As for the number of children, it was verified that a larger number of employees' children is inversely proportional to the chances of human errors in the analyzed case.

As in any study, some limitations should be highlighted. First, the cross-section of this research restricted only the confirmation of causal relationships over the expected relationships between variables, disregarding the effect of time along this process. In addition, the present study was carried out in a sample composed exclusively of workers in a specific sector of mining, although this was the objective of the study. As these results cannot be generalized to the general population, it is suggested that future studies consider more heterogeneous samples in other types of industries.

PRACTICAL IMPLICATIONS

Evidence from this study shows the importance of considering the influence of external causes as the behavior of the employees of the company analyzed and possibly this is the reality of many others. Errors are not causes but consequences and that it is possible to manage them, at least part of them (Reason, 2000). Thus, the need for managerial strategies that can alleviate the imbalance of psychological and physiological functions are relevant and deserve attention. In this sense, a sustainable organization is one that provides its employees

with a balance between their personal and professional lives, as well as building a friendly social environment within the company and taking care of their employees' interpersonal relationships (Jarosławska-Sobór, 2015).

The Amoah & Stemn (2018) research showed that all representatives of coal Ghana's companies considered social relations and occupational safety to be key values in contemporary management and the respondents by Jarosławska-Sobór (2015) evaluated that safety at work actions organized for the employees are essentials in order to improve the current situation of the companies. In this sense, according to the Occupational Safety and Health Administration (OSHA), health promotion in the workplace produces a return to each euro invested on the investment of 2.5 to 4.8 euros thanks to the reduction in costs related to absenteeism. Still according to OSHA (2010), individual measures to promote health in the workplace through psychosocial monitoring and anti-stress training contribute to mental well-being. In this way, some management measures are suggested that can be used for such purposes:

I. The measurement of the level of stress in regular cycles can help detect the alarming levels of this symptom in the employees and predict possible future imbalances. To achieve this aim, it is recommended to regularly apply questionnaires as a way of monitoring and, in addition, it is possible to implement mechanisms of reporting life events in projects with partnerships with psychologists as a routine for the management of life events of miners and in order to pay more attention to the psychological stage of workers (Wenwen et al, 2011);
II. Stress could be diminished in some situations with feedback to employees about professional or even personal development about something that might be compromising the activity. According to Consoni (2010) feedback is a great management tool that helps in improving workers' skills and in the opportunity for behavior changes;
III. Another suggestion for the promotion of extra-occupational health is the incentive to sports practices of employees by means of agreement betwenn the company and academies, wherw this last could be offer discount on the tuition. In addition, the company could encourage employee participation in sports competitions and offer subsidies in races, athletic walks, tournaments stimulating the practice of sports and improving the psychosocial aspect of workers. Companies such as Vale, Unimed Rio, and Deloitte carry out some of these practices (Melo, 2016);
IV. The companies can create mobile clinics within their unit for consultation with dentists, psychologists, lawyers, nutritionists, physiotherapists, couples therapists, work gymnastics, motivational lectures, among other measures (FIRJAN, 2018). Consequently, employees

could have more contact with professionals specialized in solving problems that affect their personal lives and in return the company would reduce the human errors and the absenteeism due to exits for such services. In addition, gymkhanas, group dynamics, coffees break could be created aiming at more integration among the employees. Thus, workers could integrate more and create more bonds of friendship.

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Como Referenciar este Artigo, conforme ABNT:

FLORIS, L. M; CARVALHO, E. G; FAUSTINO, B. C. R; CALEGARIO, C. L. L. Workplace Accidents as a Consequence of Human Error: An Empirical Study in a Gold Mine. **Rev. FSA**, Teresina, v.18, n. 01, art. 4, p. 74-99, jan. 2021.

Contribuição dos Autores	L. M. Floris	E. G. Carvalho	B. C. R. Faustino	C. L. L. Calegario
1) concepção e planejamento.	X	X	X	X
2) análise e interpretação dos dados.	X	X	X	X
3) elaboração do rascunho ou na revisão crítica do conteúdo.	X	X	X	X
4) participação na aprovação da versão final do manuscrito.	X	X	X	X