



Factors that make up safety culture: a look at mining industry

Fatores constituintes da cultura de segurança: olhar sobre a indústria de mineração

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Abstract: The efforts made by researchers to understand the dynamics of work-related accident prevention are remarkable but not enough to exhaust the subject. The occurrence of such events implies significant losses for society, organizations and families, in addition to the injured individuals subject to the accident. This kind of phenomenon that still happens in contemporary organizations requires not only a purely mechanistic view but also the understanding of interpersonal relations in the employment context, which refers to the organizational culture. As a quantitative analysis, this study aimed to test a model related to the culture of safety in workplace, present in the literature, in the Brazilian mining industry. Based on the initial results and on the requirements pointed out by a group of security experts in this field, we suggested adjustments in the model and it was re-tested. The results confirmed the model applied in this study and they indicated that factors related to the culture of safety in this specific environment are organizational learning, information and commitment.

Keywords: Assessment of safety; Labor safety; Culture of safety; Mining industry.

Resumo: São notáveis, ainda que insuficientes, os esforços empreendidos por pesquisadores, visando compreender a dinâmica relacionada ao processo de prevenção de acidentes de trabalho. A incidência de tais eventos implica significativas perdas para a sociedade, para as organizações e para as famílias, além dos próprios indivíduos acidentados. Para esse fenômeno, ainda presente nas organizações contemporâneas, não basta uma visão unicamente mecanicista, mas o entendimento das relações interpessoais no contexto laboral, o que remete à cultura organizacional. A partir de uma análise quantitativa, este trabalho buscou testar um modelo de diagnóstico de cultura de segurança do trabalho, presente na literatura na indústria de mineração brasileira. A partir dos resultados iniciais e de requisitos apontados por um grupo de especialistas da área de segurança, ajustes foram sugeridos e o modelo foi novamente testado. Os resultados validaram o modelo construído e ajustado para esta pesquisa e indicaram que os fatores constituintes da cultura de segurança na realidade estudada foram: aprendizagem organizacional, informação e comprometimento.

Palavras-chave: Diagnóstico de segurança; Segurança do trabalho; Cultura de segurança; Indústria de mineração.

1 Introduction

The issue of occupational safety has been a matter of concern in organizations and academia due to the relevance of the financial and non-financial losses resulting from fatalities, injuries and diseases, which impact organizations, society, the families of the victims and, of course, the victims themselves.

In Brazil, the number of occupational accidents has remained high. In 2010, 2011, and 2012, respectively, there were 709,474, 720,629 and 705,239 occupational

accidents reported (Brasil, 2012). The strategies used by companies in Brazil to deal with this problem range from the controls established by the various existing rules, the precepts of which are established in Chapter V of the Consolidated Labor Law (CLT), to actions aimed at intervention and monitoring of human behavior within organizations. In this sense, a point that attracts attention is the application of personnel development practices, which often

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concentrate efforts on observable behavior, individual and isolated, disregarding the cultural processes that contribute to the occurrence work-related accidents.

Therefore, whenever aspects related to workplace safety flaws cannot be clarified after investigations, answers are sought in the organizational culture, according to Guldenmund (2010). Since this concept was presented in the Chernobyl nuclear accident investigation report, it has been considered a key factor for safety in organizations (Naevestad, 2009).

The safety culture has been understood as a result of the perceptions, attitudes and behaviors of individuals in organizations, since the organizational context can model behaviors in terms of importance and probability (Harvey et al., 2002). Naevestad (2009) discusses two main approaches: functionalist and interpretive. The first, the basis of this study, focuses on the power of cultural transformation on managers and the sharing of patterns of behavior. The second is structured through the interaction of the members of the organization, through the sharing of patterns of meanings.

Many taxonomies have been developed by researchers, such as Geller (1994), Hudson (2003) and Westrum (2004), to categorize the possible stages of the safety culture and seek to understand their indicators. Gonçalves et al. (2011, 2013), in turn, developed a safety culture diagnostic model for industry, based on Hudson's (2003) proposal, which was later applied in the chemical and petrochemical segments.

The importance of work safety and using reference models that have broad scope and include the particularities of various economic sectors serve to attract scientific investigation and subsequent application of the findings by businesses.

Therefore, this study had two objectives. The first was to apply a safety culture diagnosis model (Gonçalves et al., 2011) to a Brazilian mining company, highlighting the factors that constitute its work safety culture. The second aim was to adapt this model to the reality of the mining industry. These adjustments occurred and were tested according to the needs pointed out by a group of work safety experts specialized in the mining industry, based on Gibbons et al. (2006) and Balassiano & Salles (2012).

The relevance of the study comes both from the suggested adjustments to the model of Gonçalves et al. (2011), used as reference, and the need to learn more about the aspects most closely related to strengthening the safety culture in the mining industry. This is a topic still little explored in Brazil, where the mining sector employs a large contingent of workers. In mid-2014, the total labor force in the Brazilian mining sector was over 198 thousand workers (DNPM, 2014).

2 Theoretical framework

The concept of culture is used to explain the fact that different groups of people have different ways of absorbing and reacting to events based on gradual learning and sharing of meanings (Zanelli et al., 2004). In this way, culture can be considered a vector that influences and structures the ways of thinking, feeling and acting.

According to Martin (2002), one of the perspectives to understand culture in organizations is that of integration, where the culture is considered to be homogeneous, because its aspects are shared by the majority of members, producing consistent and clear interpretations of their manifestations.

Among several models identified by Smircich (1983), the comparative management model stands out. Based on a functionalist understanding of organizational culture, this model is characterized by the interpretation of organizations as organisms in a setting that presents imperatives for behavior.

Organizational culture can be defined by the sharing of beliefs, perceptions and thoughts, and can be manifested through artifacts - such as visible organizational structures and processes - and by expressed values (Schein, 1992), where such sharing characterizes groups of people (Schneider & Smith, 2004).

Several typologies intend to explain the organizational culture construct. One of the approaches is that of Cameron & Quinn (1999), who proposed four classifications of culture: clan, adhocracy, hierarchy and market cultures. The clan culture is characterized by cohesion, loyalty and internal maintenance. The adhocracy culture is marked by innovation, pioneering and flexibility. The hierarchical culture presents structured, bureaucratic, stable processes and has discipline as an important trait. Finally, in the market culture there is emphasis on external positioning and control.

Berson et al. (2008) indicated three dimensions that are recurrently identified in organizational culture: innovation, bureaucracy and support. The innovation dimension has entrepreneurial characteristics, where creativity and taking risks are valued. In the bureaucratic dimension, the focus is on rules and efficiency. The support dimension is marked by the relationship between the members of the organization, which ideally should be friendly, fair and attentive.

These and other typologies are references that help to characterize the culture of a given organization, to allow its understanding and the diagnosis, planning and implementation of interventions that support the organization in meeting business demands, in light of its strategies, and in a procedural vision intrinsic to the management of culture. All this, of course, applies to the job safety issue.

Safety culture is part of organizational culture (Guldenmund, 2010; Richter & Koch, 2004). When organizational culture prioritizes work safety, then safety culture is present in the organization (Glendon & Stanton, 2000; Silva & Lima, 2004).

When exploring the advances of the literature related to the understanding of the safety culture aspects, it reveals an expansion from a technician, functionalist and legalist vision to visions that are more geared to management and cultural processes. Safety, along with health, has been incorporated into management systems, seeking, besides compliance with legislative rules and administrative standards, improvement in behavior and recognition of the contribution of safety culture to the good management of the organization.

Reason (2016), in an attempt to understand safety culture, defines it as the set of shared values and beliefs that interact with organizational structures and control systems to produce behavioral norms. In addition, he advocates four main aspects in the safety culture process: (i) culture of reporting, in which people perceive the importance of reporting workplace accidents and feel confident in doing so; (ii) culture of continuous learning; (iii) culture of justice, which generates confidence so that people freely report abnormal occurrences that may occur; and finally, (iv) flexibility, which translates into the organization's ability to consider a horizontal structure that allows more autonomy. This concept and the processes are corroborated by Gibbons et al. (2006), Richter & Koch (2004), and Zanelli et al. (2004), who have highlighted the cultural diversity that can coexist in a group and in groups within an organization.

Despite the diversity within the field of research on safety culture, Naevestad (2009) distinguishes two main approaches: the functionalist and the interpretative. The functionalist approach is the most widely used because it is easier to observe, measure and transform, since it assumes that culture refers to the sharing of behavior patterns rather than meanings, as advocated by the interpretative approach. The functionalist line is generally preferred by managers due to the attribution of the power of cultural transformation. The interpretative approach, however, focuses on the meaning that people attribute to actions and safety systems, by sharing the patterns of meaning that members of the organization attribute to their beliefs, behaviors and collective identity. In addition, this author believes that in the interpretative approach, culture is created and recreated through the interaction of group members.

As for the process of developing safety culture, Geller (1994) pointed out three stages: dependent, independent and interdependent. However, Fleming (2001) defined five stages of the evolutionary process: emergent, management, involvement, cooperative

and continuous improvement. The International Atomic Energy Agency (IAEA, 2002) indicated three stages of safety culture. In the first stage, the practice of work safety occurs through compliance with rules and regulations and employees perceive it as a concern of their leaders. In the second stage, the focus is on performance, which is driven by objectives and goals. In the third stage, safety is understood as a process that must be continuously improved, in which everyone can contribute. Another proposal to classify the stages safety culture was put forward by Westrum (2004), who focused attention on the role of information in the development of safety culture, encompassing three stages of culture: pathological, bureaucratic and constructive.

Hudson (2003) proposed a model of evolution of safety culture maturity that includes five stages: pathological, reactive, calculative, proactive and constructive. The pathological stage is characterized by the absence of worries about job safety, which is considered a problem caused by workers, and the main drivers are business considerations and the desire not to get caught by inspectors or officials. In the reactive stage, organizations begin to take the safety issue seriously, but they only react after accidents. In the calculative stage, there are systematic actions aimed at quantifying the results, that is, this is a step focuses on collecting data rather than learning from them, but safety is still something imposed and not sought by the workforce. The proactive stage is marked by anticipating problems by promoting continuous improvement and assuming organizational values as a reference for work routines. Involvement of the workforce begins to happen, in place of the purely top-down approach. The last level, the constructive or generative one, is characterized by active participation at all levels to achieve continuous improvements, in which safety is integrated with everything the organization does and safety becomes part of the business.

From a survey of several typologies proposed in the literature, Gonçalves et al. (2011) developed a model that allows the identification of the maturity of an organization's safety culture. The authors based their framework on the taxonomy proposed by Hudson (2003), and carried out an extensive literature review to characterize and identify the stages, in which five factors indicative of the maturity of the safety culture were selected. They are: information, organizational learning, communication, commitment and involvement.

The information factor refers to individuals' confidence in the reporting of deviations to managers, and also includes the indicators developed to measure work safety performance. Organizational learning refers to how the organization handles accident-related data, whether it includes the dissemination of information to employees and whether there is a continuous process

evolution. The communication factor refers to the extent to which information about job safety reaches employees, whether there is an open channel between employees and managers, and whether the organization measures the effectiveness of the communication process. Commitment refers to the resources allocated to work safety management, the status of production, values, policies, procedures and training processes and whether these contents really are coherent between discourse and practice. Finally, involvement addresses the level of employee involvement in safety issues, such as accident investigations and the establishment of safety committees.

Therefore, Gonçalves et al. (2011) pointed out these five factors (information, organizational learning, communication, commitment and involvement) to be treated in the five maturity levels of safety culture - pathological, reactive, calculative, proactive and constructive (Hudson, 2003) - aiming to diagnose safety culture and establish actions for its maturation (Figure 1). The increase of confidence and information boost maturity levels.

Given the model, the authors tested it in 23 chemical and petrochemical companies, obtaining its validation for these industries and indicating the possibility of generalization to all industrial organizations.

3 Methodology

For this study, the concept of safety culture is defined as the sharing of values, beliefs, perceptions, and meaning patterns about the safety issue in organizations. We used the functionalist approach, as proposed by Naevestad (2009), and the model described by Gonçalves et al. (2011), due to its breadth and focus on the industrial sector. Although the mining industry, the subject of this study, has different characteristics compared to those in the chemical and petrochemical segments, where the model was previously applied, we chose it to seek

possible evolution and adaptations to the mining industry.

Therefore, to achieve the objectives, we obtained the data by application of a structured questionnaire, as proposed by Gonçalves et al. (2011). This allows, according to Creswell (2010), obtaining a quantitative description of the attitudes, opinions and tendencies of the population from the responses of the people included in the sample.

The data collection took place in two stages, with two different questionnaires, called the original questionnaire and the adjusted questionnaire. The first was exactly the one proposed by Gonçalves et al. (2011). The second reflected adaptations based on the mining sector's specific characteristics. In this way, it was possible to verify which questionnaire best applies to the mining sector, and consequently, the resulting model.

The original questionnaire consists of 21 (twenty-one) observable variables, one for each question, covering the 5 (five) factors indicative of maturity of safety culture - information, organizational learning, communication, commitment and involvement. They are, respectively, 4 (four), 4 (four), 3 (three), 8 (eight) e 2 (two) questions for factor, as presented in Chart 1. Each question indicates 5 options related to each of the predicted degrees of maturity - pathological, reactive, bureaucratic, proactive and constructive.

The adjusted questionnaire was composed of 22 (twenty-two) questions, with 4 (four), 4 (four), 2 (two), 9 (nine) and 3 (three) questions, respectively, for each factor, as shown in Chart 2. Like the original questionnaire, each question indicates 5 options regarding each predicted degree of maturity. The adjustment involved the inclusion of two new variables entered and the deletion of one. Regarding the new variables, one was related to the leadership role, extracted and adapted from Gibbons et al. (2006) on the development and initial validation of a method for accessing the safety culture in commercial flight operations in

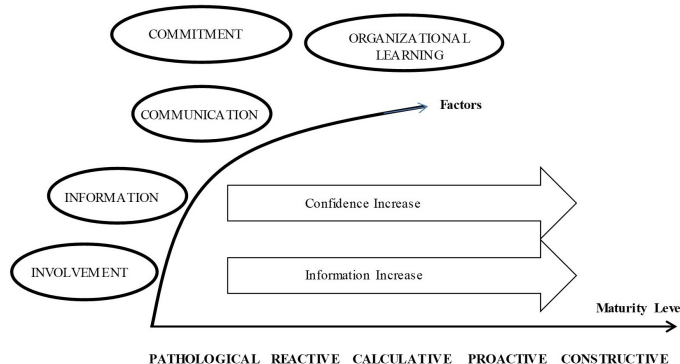


Figure 1. Factors of Safety Culture and Degree of Maturity. Source: Prepared by the authors based on Gonçalves et al. (2011) and Hudson (2003).

Chart 1. Original questionnaire.

INFORMATION	4 questions related to information on abnormal occurrences, information means, employee confidence, and performance measurement indicators.
ORGANIZATIONAL LEARNING	4 questions related to the analysis of abnormal occurrences, method of analysis, improvements in safety, and the results of the analysis of these occurrences.
COMMUNICATION	3 questions related to the company’s communication on safety at work, the existence of information channels, and the effectiveness of this communication.
COMMITMENT	8 questions related to the company’s support for workplace safety: planning, audits, investments, priority, training, authority, safety procedures, and monitoring of contractors.
INVOLVEMENT	2 questions related to employee participation in job safety and interest in participating.

Source: Gonçalves et al. (2011).

Chart 2. Adjusted questionnaire.

INFORMATION	4 questions related to information on abnormal occurrences, information means, employee confidence, and performance measurement indicators.
ORGANIZATIONAL LEARNING	4 questions related to the analysis of abnormal occurrences, method of analysis, improvements in safety, and the results of the analysis of these occurrences.
COMMUNICATION	2 questions related to the existence of information channels, and the effectiveness of this communication.
COMMITMENT	9 questions related to the company’s support for workplace safety: planning, auditing, investments, training, authority, priority, safety procedures, leadership performance and compliance.
INVOLVEMENT	3 questions related to the participation of outsourced workers, the involvement of contracted workers and the interest in participating.

Source: Prepared by the authors.

the United States; and the second was related do the justice in relationships, a content developed by Balassiano & Salles (2012). The deleted variable was the one associated with communication – existence of a company-employee communication factor, which did not apply to the reality of the company studied, according to the team of specialists interviewed.

The research subjects were the technical-operational level employees of an industrial unit of a Brazilian mining company. The universe of this research, it means, the total of employees was 590. The sample was selected by the accessibility criterion, defined by the ease of access to the research subjects, and it counted on 288 respondents (48.8% of total employees). Part of that contingent, 161 (27.3%), answered the original questionnaire, while 127 (21.5%) answered the adjusted questionnaire. Therefore, the number of observations in both samples is adequate, since 5 to 10 observations per item (questionnaire questions) are indicated as sufficient.

The profile of the participants was detailed in the questionnaires, given the application of two different types of questionnaires, in two equally distinct samples from the same company. Table 1 compares the profiles of the two groups of respondents.

Because the first objective was to detect the factors that constitute the safety culture and the cultural aspects related to the generation of accidents, both

questionnaires - the first with 21 observable variables and the second with 22 observable variables – were subjected to the same factor analysis to detect these factors. According to Hair et al. (1998, 2009), factorial analysis seeks to analyze the structure of interrelationships (correlations) between a large number of variables, defining a set of common underlying dimensions, known as factors.

Due to the second objective of adapting the diagnostic model to the reality of the mining industry, and although it was faced with an eminently confirmatory problem, we carried out an exploratory evaluation, in line with Balassiano (2006), with three new tests to identify new factors beyond the 5 previously established ones. The first test employed the standard software process applied to factor analysis, which identified 7 (seven) factors. In the other tests, 3 (three) and 4(four) factors were identified.

The premises of normality, linearity and multicollinearity required by factor analysis were met.

4 Analysis of the results

The data obtained through the original and adjusted questionnaires considered the five pre-established factors and were adequate for conducting the factor analysis, which was confirmed by the Kaiser-Meyer-Olkin

Table 1. Samples' characterization.

Sample Profile Details	Original Questionnaire Sample		Adjusted Questionnaire Sample	
	Absolut Numbers	Relative Numbers	Absolut Numbers	Relative Numbers
Female	2	1.24%	2	1.57%
Male	159	98.76%	125	98.43%
Leaders	16	9.94%	15	11.81%
Primary Education Completed	4	2.48%	4	3.15%
High School Diploma	126	78.26%	95	74.80%
College Diploma	27	16.77%	20	15.75%
Advance College Degree	4	2.48%	8	6.30%
Less than 1 year with the Company	41	25.47%	13	10.24%
Between 1 and 5 years with the Company	70	43.48%	51	40.16%
Between 6 and 10 years with the Company	27	16.77%	36	28.35%
Between 11 and 15 years with the Company	1	0.62%	4	3.15%
More than 15 years with the Company	22	13.66%	23	18.11%
Average Age	33		34.7	
Participants	161		127	

Source: Prepared by the authors.

Table 2. Adequacy of the factor analysis technique of the original questionnaire.

KMO and Bartlett Tests	Values
Kayser-Meyer-Olkin (KMO) measure of sampling adequacy	0.728
Chi-squared approximation	867.561
Bartlett's sphericity test	210
Significance	0.000

Source: Prepared by the authors.

Table 3. Adequacy of the factor analysis technique of the adjusted questionnaire.

KMO and Bartlett Tests	Values
Kayser-Meyer-Olkin (KMO) measure of sampling adequacy	0.76
Chi-squared approximation	1120.789
Bartlett's sphericity test	231
Significance	0.000

Source: Prepared by the authors.

(KMO) and Bartlett sphericity tests, with significance below 5%, as shown in Tables 2 and 3.

The KMO test produces a statistic that indicates the proportion of data variance that can be considered common to all variables. Results between 0.5 and 1.0 mean adequacy of the factor analysis (Hair et al., 1998, 2009). The Bartlett sphericity test checks whether the correlation matrix is an identity matrix, which would indicate that the factorial model is inappropriate. With a significance level lower than 5%, the null hypothesis that the correlation matrix is an identity is rejected, thus allowing the continuation of the analysis.

When conducting the factor analysis of the data obtained through the original questionnaire, it can

be seen in Table 4, that the commonalities, which refer to the estimated variance of the variables, were between 0.273 and 0.669. It is important to note that, according to Hair et al. (1998, 2009), practical considerations suggest a minimum level of 0.5 for commonalities in statistical analysis. Therefore, with such low commonalities, the variables of the original questionnaire did not present the expected correlations with the previously defined factors, that is, the contribution of each variable to the model constructed by the factorial analysis was modest.

The variables previously related to information (INFO) did not correlate in the same factor, but they were present in other factors, besides presenting cross-loadings even after rotation of the factors.

Table 4. Commonalities and rotated factor matrix of the data collected by the original questionnaire.

Variables	Commonalities Extraction	Rotated Factor Matrix Components				
		1	2	3	4	5
INFO1	0.402	0.150	0.274	0.434*	0.325	0.104
INFO2	0.665	0.056	0.735*	-0.238	-0.013	0.256
INFO3	0.563	0.337	0.080	-0.454*	-0.479*	0.087
INFO4	0.641	0.258	0.044	0.130	0.744*	0.040
ORGLEARN5	0.462	0.368	0.008	-0.128	0.537*	-0.148
ORGLEARN6	0.371	0.191	0.080	0.498*	-0.158	0.236
ORGLEARN7	0.506	0.656*	0.142	0.124	0.201	-0.008
ORGLEARN8	0.455	-0.072	0.608*	0.261	0.102	0.046
COMMUN11	0.563	0.034	0.348	0.266	0.132	0.594*
COMMUN12	0.397	0.079	0.562*	0.136	-0.182	-0.154
COMMUN13	0.554	0.409	0.273	0.555*	0.064	0.007
COMMMIT14	0.273	0.343	0.327	0.066	0.176	-0.116
COMMMIT15	0.529	0.304	0.566*	-0.092	0.327	0.031
COMMMIT16	0.636	0.728*	0.037	0.094	0.271	-0.153
COMMMIT17	0.430	-0.087	0.102	-0.629*	-0.065	0.108
COMMMIT18	0.365	0.579*	0.040	0.011	0.130	0.106
COMMMIT19	0.479	0.515*	0.115	0.406	0.076	-0.170
COMMMIT20	0.669	0.470	0.561*	0.025	-0.052	-0.362
COMMMIT21	0.558	-0.099	-0.224	-0.143	-0.158	0.673*
INVOLV9	0.610	0.525*	0.398	0.045	0.014	0.417
INVOLV10	0.549	0.681*	0.023	0.270	-0.110	0.026

*> 0.40 acceptable contribution limit of variable in factor creation. Source: Prepared by the authors.

Regarding the variables related to organizational learning (ORGLEARN), there was also no correlation between them in a single factor. On the contrary, they were all positioned in different factors, in exactly the same way as the variables related to communication (COMMUN) and involvement (INVOLV). Such results demonstrate that the chosen variables were not confirmed as good representatives of the previously defined factors.

Regarding the variables related to the commitment factor (COMMMIT), the great majority had significant factor loadings (> 0.5) and they were correlated mainly to two factors.

In the factor analysis with the data collected by the adjusted questionnaire, according Table 5, the commonalities varied between 0.479 and 0.776, indicating better results regarding the shared variance with all variables analyzed in relation to those obtained with application of the original questionnaire.

Regarding the rotated factor matrix (Table 5), it showed significant consistency in the results and a higher correlation of the variables with the factors defined *a priori* in relation to the test performed with the data collected by the original questionnaire.

It could be noted that the results of the adjusted questionnaire showed that most of the variables

related to latent factors: information (INFO1, INFO2, INFO3), organizational learning (ORGLEARN5, ORGLEARN6, ORGLEARN7 and ORGLEARN8), commitment (COMMMIT12, COMMMIT13, COMMMIT14, COMMMIT15, COMMMIT16, COMMMIT17, COMMMIT18), and involvement (INVOLV20, INVOLV21) had correlations within the same component or factor.

Most of the information-related variables (INFO) correlated to a single factor, except for the fourth variable (INFO4), which was positioned in the same way as the variables related to organizational learning (ORGLEARN). This correlation can be explained by the fact that variable INFO4 deals with the performance evaluation models of the company. It is possible to infer that this content is associated with organizational learning, to the extent that the organizational indicators, when well used and analyzed, catalyze the learning process. Like this last factor, if well accomplished, it will necessarily have positive impacts on the organization's performance. Thus, the possibility of understanding of the correlation between the variable INFO4 and the variables related to organizational learning (ORGLEARN) is clear.

The results of the variables related to communication (COMMUN) did not present a correlation with a

Table 5. Commonalities and rotated factor matrix of the data collected by the adjusted questionnaire.

Variables	Commonalities	Rotated Factor Matrix				
		Components				
	Extraction	1	2	3	4	5
INFO1	0.564	0.054	0.025	-0.056	0.745*	0.054
INFO2	0.496	-0.070	0.191	-0.110	0.663*	0.054
INFO3	0.493	0.254	0.123	0.344	0.538*	-0.077
INFO4	0.539	-0.020	0.706*	-0.048	0.049	0.189
ORGLearn5	0.590	0.177	0.625*	0.065	0.398	-0.075
ORGLearn6	0.459	0.074	0.658*	-0.037	0.005	0.140
ORGLearn7	0.776	0.485	0.632*	0.308	0.169	-0.135
ORGLearn8	0.513	0.083	0.541*	0.315	0.330	-0.075
COMMUN9	0.744	0.133	0.121	0.146	0.138	0.819*
COMMUN10	0.549	0.245	0.141	0.369	0.547*	0.185
COMMMIT11	0.595	0.289	0.278	0.526*	-0.055	0.393
COMMMIT12	0.613	0.584*	0.299	0.273	-0.062	-0.323
COMMMIT13	0.643	0.541*	0.264	0.091	-0.046	0.520
COMMMIT14	0.676	0.688*	-0.097	-0.239	0.194	0.314
COMMMIT15	0.537	0.639*	0.042	0.316	0.138	0.095
COMMMIT16	0.673	0.560*	-0.065	0.543	-0.145	0.197
COMMMIT17	0.493	0.665*	-0.100	0.179	0.016	0.087
COMMMIT18	0.698	0.777*	0.153	0.248	0.029	0.094
COMMMIT19	0.524	0.192	-0.113	0.602*	0.253	0.221
INVOLV20	0.542	0.651*	0.288	0.015	0.185	-0.037
INVOLV21	0.508	0.585*	0.272	0.249	0.121	0.124
INVOLV22	0.541	0.141	0.101	0.710*	-0.042	-0.017

*> 0.40 acceptable contribution limit of variable in factor creation. Source: Prepared by the authors.

single factor. On the other hand, the commitment (COMMMIT), 7 (seven) of the 9 (nine) variables behaved similarly, correlating with a single factor, demonstrating that representations of this factor are adequate. Although there was cross-loading of the variable COMMMIT16, only the first (COMMMIT11) and the ninth (COMMMIT19) variables of this factor disagreed with the others, showing inadequacy for this model. The variable COMMMIT11 is related to the planning of companies in relation to work safety, and COMMMIT19 was fully constructed in this study and concerns justice in relationships.

Regarding involvement (INVOLV), most of its variables converged with those of commitment (COMMMIT), demonstrating that those concepts are not being distinguished by the data.

When comparing the results of the two questionnaires, although in the analysis of the data of the adjusted questionnaire not all the variables behaved according to expectation, the correlations were closer to the ones expected, according to the conceptual objective. Most of the variables related to organizational learning (ORGLearn), commitment (COMMMIT) and information (INFO) presented important correlations within the preconceived

factors, which did not occur from the analysis of the data of the original questionnaire.

Regarding the variables related to communication (COMMUN) and involvement (INVOLV), neither of the two models tested had the predicted correlations.

We applied other tests to the data from the adjusted questionnaire, as follow: the first one was according to the standard of the software used in this study, which establishes the number of factors according to eigenvalues greater than 1 (one), in this case, 7 (seven) factors. The second one was performed suggesting 3 (three) factors, and the third, 4 (four) factors.

As can be seen in Table 6, the commonalities resulting from the seven-factor test varied between 0.581 and 0.793, i.e., higher than those obtained in the five-factor test. However, in rotated factor matrix, although there were factor loadings greater than 0.5, the position of most of the other variables did not present the expected correlations from previous conceptual evaluations.

When testing the adjusted data considering three factors, as shown Table 7, the commonalities varied between 0.259 and 0.769, that is, with values lower than those obtained in the tests with five and seven factors. However, it is possible to observe in

Table 6. Commonalities and rotated factor matrix with seven factors from the adjusted questionnaire.

Variables	Commonalities	Rotated Factor Matrix							
		Extraction	Components						
			1	2	3	4	5	6	7
INFO1	0.606	-0.023	0.125	0.761*	0.075	0.023	0.046	-0.037	
INFO2	0.652	0.080	-0.074	0.677*	0.204	-0.003	-0.306	0.216	
INFO3	0.588	0.204	0.185	0.522*	0.085	-0.009	0.479	0.049	
INFO4	0.657	0.053	-0.012	0.093	0.795*	0.109	0.019	-0.013	
ORGLearn5	0.607	0.398	0.018	0.389	0.518*	0.008	0.153	-0.069	
ORGLearn6	0.581	0.087	0.074	0.045	0.748*	0.064	0.042	-0.010	
ORGLearn7	0.793	0.669*	0.180	0.125	0.458*	-0.008	0.191	0.226	
ORGLearn8	0.759	0.705*	-0.329	0.243	0.156	0.196	0.058	0.171	
COMMUN9	0.784	0.001	0.096	0.105	0.095	0.843*	-0.046	0.205	
COMMUN10	0.702	0.372	0.037	0.477*	-0.086	0.399	0.409	-0.006	
COMMMIT11	0.600	0.178	0.171	-0.084	0.266	0.425*	0.382	0.367	
COMMMIT12	0.720	0.678*	0.273	-0.120	0.123	-0.206	0.040	0.335	
COMMMIT13	0.694	0.333	0.388	-0.100	0.158	0.626*	0.076	0.005	
COMMMIT14	0.709	0.073	0.769*	0.195	0.030	0.235	-0.130	-0.042	
COMMMIT15	0.631	0.216	0.596*	0.120	0.095	0.100	0.418	0.146	
COMMMIT16	0.789	0.163	0.492	-0.168	0.029	0.134	0.260	0.636*	
COMMMIT17	0.582	0.138	0.677*	0.012	0.029	0.006	0.138	0.292	
COMMMIT18	0.711	0.543*	0.550*	-0.037	0.020	0.221	0.203	0.149	
COMMMIT19	0.781	0.126	0.093	0.221	-0.097	0.184	0.104	0.808*	
INVOLV20	0.629	0.677*	0.358	0.109	0.037	0.162	0.004	-0.059	
INVOLV21	0.625	0.576*	0.307	0.042	0.036	0.339	0.282	-0.029	
INVOLV22	0.741	0.090	0.061	-0.059	0.091	0.000	0.829*	0.176	

*> 0.40 acceptable contribution limit of variable in factor creation. Source: Prepared by the authors.

Table 7. Commonalities and rotated factor matrix with three factors from the adjusted questionnaire.

Variables	Commonalities	Rotated Factor Matrix			
		Extraction	Components		
			1	2	3
INFO1	0.501	-0.028	0.157	0.690*	
INFO2	0.480	-0.157	0.275	0.616*	
INFO3	0.355	0.304	0.319	0.401*	
INFO4	0.365	-0.024	0.594*	0.104	
ORGLearn5	0.584	0.097	0.702*	0.286	
ORGLearn6	0.323	0.052	0.564*	0.044	
ORGLearn7	0.769	0.470	0.740*	0.030	
ORGLearn8	0.474	0.146	0.641*	0.204	
COMMUN9	0.373	0.387	-0.066	0.468*	
COMMUN10	0.487	0.378	0.265	0.523*	
COMMMIT11	0.404	0.588*	0.233	0.059	
COMMMIT12	0.525	0.518*	0.444	-0.243	
COMMMIT13	0.441	0.627*	0.139	0.169	
COMMMIT14	0.415	0.353*	-0.121	0.338	
COMMMIT15	0.517	0.694*	0.139	0.127	
COMMMIT16	0.637	0.729*	-0.020	-0.097	
COMMMIT17	0.445	0.666*	-0.033	0.036	
COMMMIT18	0.658	0.780*	0.219	0.032	
COMMMIT19	0.309	0.489*	-0.009	0.264	
INVOLV20	0.413	0.510*	0.368	0.131	
INVOLV21	0.500	0.616*	0.324	0.123	
INVOLV22	0.259	0.432*	0.224	-0.148	

*> 0.40 acceptable contribution limit of variable in factor creation. Source: Prepared by the authors.

rotated factor matrix that although four variables (INFO3, COMMUN9, COMMIT19, INVOLV22) had factor loadings under 0.5, the variables correlated to three factors in a coordinated way with the expectations formed according to the conceptual objective of each of them. In addition, variables related to communication (COMMUN) and information (INFO) were correlated to a single factor, as were the variables related to commitment (COMMIT) and involvement (INVOLV).

It is possible to understand the relationship between these factors. The variables related to communication (COMMUN) and information (INFO) have very close conceptual objectives, referring to the process of information distribution within companies, whether referring to the information about accidents reported by employees (INFO1) or the communication by the Company on labor safety (COMMUN2). Thus, it can be understood that the direction of information (company to employees or employees to company) was ignored during the establishment of the correlations and these converged in a single sense.

Like other tests performed with the adjusted questionnaire data, the indicators also did not distinguish the variable INFO4 from the variables related to organizational learning, treating them in a similar way, forming a single dimension. This variable refers to the types of work safety performance assessment used by companies. Such a correlation makes sense insofar as the organizational learning process is considered to be related to organizations' ability to assess performance. Companies that have more elaborate and in-depth methods to evaluate performance are certainly more likely to have a more effective organizational learning process.

When considering 4 (four) factors to analyze the results from the adjusted questionnaire, it is possible to see, according to Table 8, that the commonalities varied between 0.406 and 0.770, that is, higher values than those obtained in the test with 3 (three) factors. On the other hand, the variables related to communication did not correlate with the same factor, and the variables COMMIT13 and COMMIT14, which in all other analysis were correlated to a single factor, did not behave in the same way in the analysis with 4 (four) factors.

Table 8. Commonalities and rotated factor matrix with four factors from the adjusted questionnaire.

Variables	Commonalities	Rotated Factor Matrix			
		Extraction	Components		
		1	2	3	4
INFO1	0.530	-0.078	0.060	0.118	0.712*
INFO2	0.485	-0.184	0.215	0.051	0.634*
INFO3	0.488	0.329	0.123	0.014	0.564*
INFO4	0.496	-0.073	0.688*	0.119	0.061
ORGLearn5	0.585	0.160	0.642*	0.012	0.384
ORGLearn6	0.440	0.006	0.650*	0.131	0.007
ORGLearn7	0.770	0.565	0.644*	0.067	0.178
ORGLearn8	0.498	0.290	0.512*	-0.101	0.376
COMMUN9	0.521	0.014	0.067	0.686*	0.214
COMMUN10	0.540	0.350	0.121	0.210	0.599*
COMMIT11	0.406	0.503*	0.205	0.327	0.058
COMMIT12	0.543	0.650*	0.336	-0.012	-0.081
COMMIT13	0.628	0.311	0.271	0.676*	-0.035
COMMIT14	0.535	0.172	-0.002	0.704*	0.099
COMMIT15	0.523	0.608*	0.065	0.358	0.146
COMMIT16	0.651	0.725*	-0.096	0.332	-0.069
COMMIT17	0.445	0.530*	-0.057	0.402	-0.004
COMMIT18	0.662	0.655*	0.194	0.446	0.015
COMMIT19	0.437	0.499*	-0.179	0.150	0.365
INVOLV20	0.427	0.421*	0.358	0.325	0.123
INVOLV21	0.503	0.525*	0.292	0.356	0.126
INVOLV22	0.440	0.638*	0.019	-0.158	0.086

*> 0.40 acceptable contribution limit of variable in factor creation. Source: Prepared by the authors.

5 Final considerations

The objective of this study was to apply a diagnostic model of maturity stages of the safety culture developed by Gonçalves et al. (2011) in a company in the Brazilian mining industry, and to adapt this model to the reality of this sector.

To that end, 288 employees of a mining company answered a questionnaire based on Gonçalves et al. (2011), called original, and also an adjusted questionnaire, based on the needs pointed out by a group of experts on work safety in that industry, and in the findings of Gibbons et al. (2006) and Balassiano & Salles (2012).

The factor analysis of the data collected through the two questionnaires used enabled making some observations. The results obtained by the original questionnaire indicated it was not appropriate for the mining reality, since the selected variables were not good representatives of the factors indicative of maturity of safety culture - information, organizational learning, communication, and involvement.

However, the results obtained through the adjusted questionnaire, with the five previously established factors, proved to be more relevant. Besides this, we performed other tests with seven, three and four factors with the data from this adjusted questionnaire. The analysis of variables grouped in three factors - organizational learning, information and commitment - presented correlations very close to those expected in relation to the conceptual objectives of each variable, that is, these factors were considered in this study as the main constituent factors of the culture of work safety in the Brazilian mining industry.

While it is desirable to create a general safety culture measure that is applicable to all organizations, industries or nations, this may not be possible or worthwhile in practice, since safety culture is closely related to the structure of the organization and the nature of the work itself (Gibbons et al., 2006). It is well known that the chemical and petrochemical industries and the mining industry have different characteristics, such as the types of risks involved in the activities and the severity of the impacts of those risks when not properly controlled.

Therefore, as opportunities for future research, it is possible to emphasize the possibility of applying the same instrument to other companies in the mining segment, as well as in other industrial segments. In addition, simple and multiple case studies with effective triangulation of methods could lead to greater enrichment of the model, even if it does not lead to generalizations.

As suggestions for management, it is important to emphasize that from the knowledge of the highlighted safety culture factors, organizations can analyze their degree of maturity in regarding safety culture and, with this, formulate action plans focused on the aspects that really drive their evolution and, consequently,

the improvement in safety indicators. Prevention of work-related accidents leads both to endogenous benefits, from gains of efficiency in operational processes and improvements in the organizational climate, and exogenous ones, by preserving or improving reputation and minimizing the economic and social costs related to the occurrence of accidents.

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