



Cross-Section Study in Underground Coal Mining Association Between the Risks Identified by Workers and the Ones Established by the Companies. Boyacá-Colombia 2014

**Edith Mireya Mora
Lozano**

Dentist. Esp. Hospital Management, Epidemiology, Bioethics. Msc. Bioethics, Occupational and Environmental Health.

**Miryam Esther
Hernandez
Rodríguez**

Industrial Engineer. Esp. Occupational health. Msc. Occupational and Environmental Health.

**Cristian Duvan
Hernández
Rodríguez**

Industrial Engineer. Masters in Occupational and Environmental Health.

**Macedonio
Hernandez
Rodríguez**

Mechanical Engineer. Esp. Occupational health. Msc. Occupational and Environmental Health.

**Milciades Ibañez
Pinilla.**

Public Health Department, School of Health Sciences, Universidad del Rosario. Bogotá, DC, Colombia.

**Marcela Varona
Uribe**

Center of Research in Sciences, School of Health Sciences, Universidad del Rosario.

ABSTRACT

Introduction. Underground coal mining in Colombia is a very important productive area with many employment opportunities for human capital. Nevertheless, pneumoconiosis, muscle skeletal and mental disorders, and accidents have increased; these problems tend to increase with the National Mining Plan projected for 2019 by the Ministry of

Mines and Energy, "being the most important industry in Latin America", intensifying the entry of new technologies, number of workers and as a consequence labor risks.

Objectives. To determine the association between risks identified by workers and the ones established by the companies affiliated to ARL POSITIVA occupational risks administrator in the preventive medicine and labor, hygiene, industrial safety subprograms and characterize the activities of preventive, labor, hygiene and industrial safety medicine subprograms implemented in the companies.

Materials and methods. A cross-section study was carried out, 232 workers from 18 companies classified by size participated, the sample was statistically stratified by conglomerates.

Results. The associations were significant by: town Samacá, small companies, age/years 40-49,9, men, married, socio economic level two, education level primary completed. Slightly superior fulfillment of the legal system and in the identification and knowledge of poor risk.

Conclusions. It was found that the risks identified by the workers and established by the companies are very few and that the valid laws are barely fulfilled.

KEYWORDS : Mining, labor risk, knowledge, preventive medicine, labor health, pneumoconiosis.

Introduction

At a global level it is estimated that coal produces 40% of electricity of the planet and is the natural source of energy of greatest growth in recent years, surpassing gas, oil, nuclear energy, hydroelectric energy and even renewable energies, some countries such as Poland (94%), South Africa (92%), China (77%), Australia (76%) surpass this calculation, it is also the main fuel for iron, steel and cement production. At least 56 nations have this industry as part of their commercial relations that at the same time is part of the stock exchange market^{1,2}.

Mining activity in Colombia is a very important economic and labor sector that is rising. The relations between miners and employers present two parallel dynamics: on one side, the employers transfer risk or keep practices that do not always protect the integrity of the employee, weakening the labor relations; on the other side, the

employees keep a set of negotiations and transactions of their rights with the purpose of getting better economic income that ensure their own subsistence and that of their families. In terms of risk transference, employers blame the workers for accidents and occupational disease whether because of their behavior outside the company, for individual predisposition, or carelessness within it. While the employee carries out a set of activities that imply risks without measuring the consequences and aware of the inevitability of them, and exposes in an unreasonable manner to unnecessary risks.^{3,4,5,6,7,8,9,10}

Exposition to risks is defined as the association between the probability that an event may occur and the negative consequences of it.^{11,12} In relation to the knowledge of risks as a causal factor of occupational accidents, according to researchers at the Universidad Autónoma de Tamaulipas, Mexico-2013, "when the risk turns into an everyday

aspect of the working activity, the perception one has of it does not adjust to reality and besides it has been proven that in most cases the human being is responsible for accidents. Thus the emphasis on the design of preventive programs^{2,13}. According to numbers from the International Labor Organization – ILO in 2011 every year there are about 337 million accidents and 2,3 million deaths in the working places, which is equivalent to 6.300 deaths per day and the common denominator is human error^{14,15,16,17}.

Once the importance has been established and the parameters that are considered to be able to assess the knowledge of risk, it is worth mentioning that depending on the way in which people perceive risk in their working sites dangerous behaviors are generated, known as human errors and more exactly as accidents at work, they may arise as contradictions both at the underestimation level (which causes apathy and irrational optimism) or as an overestimation (which generates high tension, stress, and pessimism), the concept has been evolving in recent years, in spite of how complex it is to measure it because it is a subjective matter long considered as part of the popular intra-culture, now a days it has called the attention not only because of its social-working implications but also because of the familiar and economic implications that affect all the links of the production chain.^{18,19,20,21,22,23,24,25,26,27}

As a consequence of the above, on the first place there is a need to unify the concept of "risk" in becoming a common objective of the actors of the Safety at Work System, to be able to reach safe and healthy working conditions. And on second place the responsibility of understanding how the worker conceives the reality that affects them.^{11,28,29}

The causes of accidents at work are recognized as unsafe actions (behavior that may lead to accidents at work) and unsafe conditions (unsafe situations in the working environment that may lead to accidents or illnesses)^{30,31,32,33}.

Safety and health of miners at work is a complex topic since their activity is extracting mineral renewable and nonrenewable resources from earth and it is performed in a working environment of constant change.^{34,35,36} The working conditions including environmental humidity, air temperature, presence of hazardous radiations or toxic and/or explosive gases, the presence of water, dust formation and noise emissions – depend both of the mineral when extracted as well as the adjacent fitting rock, the depth of the mine and the use or no use of tools and/or technical machinery, which makes some workers be exposed to work without natural light or enough ventilation, drilling the ground or extracting the mineral, exposing them to different kinds of risks.^{37,38}

Many countries have made strong efforts to establish safe procedures for this activity; to foster the prevention of accidents at work and occupational illnesses the ILO established that on every April 28th it celebrates the World Safety and Health at Work Day, nevertheless, the global rate of mortal victims, injuries and illnesses among miners shows that it continues to be a very dangerous work. Even though at a world level mining employs 1% of the total of workers it is responsible for 8% of mortal accidents (about 15.000 victims per year), the socio economic consequences are also founded in the malfunctioning or mistakes that are done in this kind of work. The effects are at various levels such as: personal, environmental and economic level^{39,40,41}.

Considering the above, this research project characterized the activities of the preventive medicine and work, hygiene and occupational safety subprograms implemented in the underground coal mining companies and determined the association between risks identified by the workers and those established by the company in the respective hygiene and occupational safety subprograms.^{42,43}

Materials and Methods

The cross-section study in which the companies affiliated to POSITIVA ARL Occupational Risks Administrator of the department of Boyaca, in the towns of Iza, Samacá, Socha, Socotá, Sogamoso, Tasco y Tópaga^{44,45}. The companies were classified by size considering the amount of workers, big with more than 100 workers, medium size between 51 and 99 and small between 1 and 50.

The target population was obtained by listings handed by ARL PO SITIVA the number of companies was 305 and the number of workers

6.667. The sample was probabilistic, stratified, with random proportional allocation and by two-stage conglomerates: stratified by town and the conglomerates were formed keeping in mind the primary unit of sampling (PUS) the companies and as secondary unit of sampling (SUS) on the first stage companies were chosen at random (n=18) and on the second stage the workers (n=232). In choosing the subjects the following inclusion criteria were considered: workers over 18 years old, with a working experience in the mining sector of 10 years or more at the time of field work they were carrying out working activities for the selected companies and that voluntarily accepted to participate. The ones who had an active respiratory illness or under treatment were excluded^{46,47,48,49,50}.

Social demographic and occupational variables were studied classified under chemical, biological, ergonomic, physical, locative, work at heights or use of personal protection elements risks, which were measured in two structured questionnaires one individual and another of the company the base was the valid legal regulations, the questionnaire for the company was founded on Resolution 1016 of March 31st, 1989, by which the organization, functioning and way of the Occupational Health programs which employers must develop in Colombia is regulated; the internal structure developed four components: Safety and Health at Work Management System, Preventive and Occupational Medicine, Industrial Hygiene and Basic Sanitation, Industrial Safety. The second questionnaire addressed to the workers, identified knowledge on risks at work and the use of elements of personal protection, these were applied both to the company and the workers; a pilot test was applied previously to assess the instruments with the object of making the necessary adjustments of them, the application was carried out by trained personnel from the National Health Institute, who made ensured the standardization as well as getting the informed consent⁵¹.

Typing the information was done on Excel 2010 version, to guarantee the quality it was done reviewing all the questionnaires of the companies and a 30% of the individual questionnaires and processing was in SPSS (IBM SPSS Statistics) statistic software 22, 2013 version.

For the qualitative variables related with the worker such as: age, gender, socioeconomic level, marital status, educational level, among others, distributions of absolute and percentage frequency were used; for quantitative kind variables the measures of central tendency such as average and median were calculated, in the measures of variability, range and standard deviation. The same descriptive measures were used in the company variables. For the association between variables of the workers and the company the bivariate analysis was used by means of the J_i^2 (X^2) asymptotic Pearson test or the accurate Fisher tests and of plausibility (expected values less than five).

Considering: the Belmont Report, the Helsinki Declaration and Resolution 8430 of 1993 of the Ministry of Health that establishes academic, technical and administrative norms for research on health, on Title II Chapter I Article 11 on ethical aspects of research on human beings, this research was classified as minimal risk and was approved by the technical scientific committees of research and of ethics of the National Health Institute and El Rosario University. It had informed consent^{52,53,54}.

Results

The sample was made up of 18 companies that entered the study 232 working men in underground coal mines in the department of Boyaca. The percentage of workers by towns was: Iza (5,6%), Samacá (45,7%), Socha (10,3%), Socotá (12,9%), Sogamoso (3,9%), Tasco (9,1%) and Tópaga (12,5%); the companies according to size were distributed in big 40 (17,2%), medium size 22 (9,5%) and small 170 (73,3%).

As for the social demographic variables the average age of the group was 40.9±10.3 years old, with a range of 20 to 76 years old; the age groups in which the highest frequencies were presented were 40 to 49.9 and 30 to 39.9, in relation to socio economic level the one of highest frequency was two, the most frequent marital status was married followed by common law marriage and the predominant educational level of the workers was complete primary studies (Table 1).

Table N°1. Distribution of frequencies and percentages of the socio economic variables of the workers of underground mines in the department of Boyaca. 2014

Socio Demographic Variables	Description	Frequency	Percentage
Age groups	20-29.9	35	15,10
	30-39.9	71	30,60
	40-49.9	75	32,30
	50-59.9	43	18,50
	>=60	8	3,40
	Total	232	100,00
Gender	Male	232	100,00
	Female	0	0,00
	Total	232	100,00
Social economic Level	1	56	24,60
	2	117	51,30
	3	51	22,40
	4	3	1,30
	5	1	0,40
	Total	228	100,00

Among the positions or jobs performed by the 232 workers and that are at risk of labor exposition in order of frequency they were: digger 168 (72,4%), followed by coachman 22 (9,5%), winch operator and pit supervisor 15 (6,5%), each one. The positions of: unloading, re enforcer, operator and supplier represented 12 (5,2%). The workers reported having an experience in coal underground mining of less than 25 years 182 (78,4). Of 25-29,9 years 22 (9,55%) an equal or more than 30 years 28 (12,1%), with a media of 17,43 and a median of 15,00m and range 35.

The preventive medicine and work, hygiene, industrial safety subprograms were characterizes from the company management, the information collected from the structured questionnaire of the company was

Table N°2. Distributions of frequency and percentage of fulfillment of the Components of Safety and Health at Work System Management, by size of the company of underground mining in Boyacá. 2014

Size and Amount of Companies							
Component	Total questions by component	Big n=3		Medium n= 2		Small n=13	
		Affirmative Answers	Fulfillment Percentage	Affirmative Answers	Fulfillment Percentage	Affirmative Answers	Fulfillment Percentage
1. Safety and Health at Work System Management	20	12,33	61,67	5,55	45,00	5	25,00
2. Preventive and Occupational Medicine (Medical follow up and Para Clinic controls)	9	5,66	62,96	2,50	27,78	0,53	5,98
3. Industrial Hygiene and Basic Sanitation (Risks panorama and risks established by the company in general)	28	18,33	65,48	4,49	16,07	8,53	30,49
4. Industrial Safety	27	18	66,67	11,99	44,44	9,69	35,90
Total / average*	84	13,58	64,19	6,13	33,32	5,93	24,34

*average: This reflects the adjusted average of fulfillment by positive response and percentage

To determine the association between individual variables and the ones of the company 232 questionnaires were applied to the same number of workers and 18 additional questionnaires, one per company, the association was examined by ji Fisher asymptotic square test. According to the risks reported by the company and identified by the workers the most frequent ones were: trapping and use of

Marital Status	Single	32	13,80
	Married	100	43,10
	Common Law Marriage	86	37,10
	Separated	13	5,60
	Widow	1	0,40
	Total	232	100,00
Educational Level	None	2	0,90
	Incomplete Primary	77	33,20
	Complete Primary	87	37,50
	Incomplete High School	32	13,80
	Complete High School	29	12,5
	Incomplete Technical	1	0,40
	Complete Technical	4	1,70
	Complete College	0	0,00
	Total	232	100,00

Source: Individual Survey

analyzed in its four components, the companies classified as big had a better legal fulfillment. In terms of the Safety and Health at Work System Management that explains the policy, the ones responsible of the program and referred documents, the big companies stood out due to their fulfillment big companies with more than 60% followed by medium size companies. In Preventive and Occupational Medicine the small companies had a minor fulfillment record, in medical follow up and Para clinical controls; in Industrial Hygiene and Basic Sanitation risk fulfillment was found in medium size companies, the risk panorama and risks established by the company in general were considered and the industrial safety component with less fulfillment was found in small companies (Table 2).

sharp bladed tools and in the risks reported by the company and not identified by the workers the most predominant ones were: work at heights, getting hit by falling or moving objects and falls at different levels. A significant relation between risks reported by the company and identified by the worker was found in: noise (16,2%) and work on hot (8,88%). (Table 3)

Table N° 3. Association between risks identified by workers and reported by companies of underground mining in Boyacá. 2014

Risks		Yes		No		Exact Unilateral Significance	OR	Bottom Limit	Top Limit	Association
		Frequency	%	Frequency	%					
Worker and Company										
Biological	Biological	0	0,00	3	1,90	0,362	1,408	1,292	1,534	No
Ergonomic	Posture	22	19,10	16	17,60	0,461	1,109	0,544	2,260	No
	Repetitive Movements	17	17,20	13	11,10	0,139	1,659	0,762	3,611	No
	Load Handling	25	21,70	13	12,70	0,058	1,902	0,915	3,952	No
Physical	Noise	16	16,20	6	5,10	<0,001	3,598	1,35	9,59	Si
	Ionizing Radiations	41	100,00	176	100,00	1.000	-	-	-	*
	Noni Ionizing Radiations	41	100,00	176	100,00	1.000	-	-	-	*
	Extreme Temperatures	2	2,80	1	0,70	0,25	4,203	0,375	47,148	No
	Vibrations	5	7,00	6	4,10	0,269	1,768	0,521	6,002	No
Locative	Lighting	7	8,80	18	13,20	0,221	0,629	0,250	1,578	No
	Conditions of Facilities	28	27,20	59	51,80	<0,001	0,348	0,197	0,615	No
Mechanical	Order and Cleanliness	6	6,70	13	10,20	0,267	0,639	0,233	1,752	No
	Falls of level	64	54,20	59	59,60	0,256	0,804	0,468	1,38	No
Chemical	Falls at different Levels	59	50,00	60	60,60	0,77	0,65	0,378	1,117	No
	Trapping	88	69,80	54	60,00	0,088	1,544	0,875	2,724	No
	Hit by falling or moving objects	79	66,90	79	79,80	0,024	0,513	0,275	0,956	No
Work	Use of Sharp bladed tools	52	40,90	34	38,80	0,372	1,142	0,656	1,987	No
	Exposure to coal dust	38	27,90	26	32,10	0,309	0,82	0,451	1,492	No
Work	Exposure to substances	67	52,80	46	51,70	0,493	1,044	0,607	1,796	No
	At heights	34	100,00	183	100,00					*
	On hot	3	8,88	1	0,50	0,01	17,61	1,77	174,79	Si
	Confined Spaces	2	3,20	1	6,50	0,27	0,47	0,1	2,21	No

*The measures of association for the Contingency Table were not calculated. At least one variable of each of the two ways tables over the ones in which the associations measures were calculated is a constant.

Regarding the supply of personal protection elements (PPE) on part of the company and the use of them by the workers it was greater in: helmet, bait gloves, life safety rope, rope with lampholder and in terms of personal protection elements that are not used by workers, they were: steel toe boots and rubber boots. The association between the use of personal protection elements by the workers and supplied by the company was significant in respiratory protection with cartridge, additive or hearing protection of the insertion type, outer cups, rope with lampholder, leather boots and life safety rope (Table N° 4)

Table N° 4. 2014 Association between PPE used by workers and by underground mining companies in Boyacá. 2014

Personal Protection Elements PPE	Yes		No		Exact Unilateral Significance	Reason of Advantages OR	Bottom limit	Top limit	Association	
	Frequency	%	Frequency	%						
Head Protection	Helmet	208	100,00	24	100,00	-	-	-	-	*
Visual Protection - goggles	Polychromatic	18	100,00	10	90,90	0,390	0,357	0,217	0,587	No
	Net kind	0	0,00	1	3,70	0,931	1,077	0,972	1,193	No
Hearing Protection	Insertion kind.	46	78,00	11	22,40	<0,001	12,220	4,917	30,390	Yes
	Hard cup.	45	80,40	6	11,50	0,000	31,360	10,690	92,010	Yes
Respiratory Protection	Disposable mask	38	45,80	40	33,30	0,050	1,689	0,950	3,001	No
	Cartridge	119	75,80	10	22,70	0,000	10,650	4,813	23,560	Yes
Upper limbs protection-gloves	Bait	179	91,80	31	83,80	0,110	2,165	0,786	5,962	No
	Calfsking	7	21,20	16	8,00	0,280	3,079	1,157	8,193	No
Feet Protection Boots	Rubber	47	72,30	158	94,60	<0,001	0,149	0,063	0,353	No
	Leather	18	36,70	10	5,50	0,000	10,050	4,241	23,800	Si
	Steel toe	81	98,80	142	94,70	0,112	4,563	0,561	37,140	No
Others	Rope with lampholder	95	77,20	60	55,00	<0,001	2,771	1,774	4,879	Yes
	Life Safety Rope	62	78,50	39	25,50	<0,001	10,660	5,575	20,380	Yes

*The measures of association for the Contingency Table were not calculated. At least one variable of each of the two ways tables over the ones in which the associations measures were calculated is a constant.

Discussion

Recent studies like the ones carried out by FEDESARROLLO, the Colombian Ministry of Mines and Energy – CMME, the Mining Development Plan among others, highlight the fact that the mining policy in the country was not founded in terms of the mining resource nor as a stimulus for the income of the working population, but as a drive to the so called “investor trust” in which freedom of market predominates for the individuals or organizations that have the necessary private working capital may access the minerals and exploit them. The Ministry – MMEC, has set the goal that in the year 2019 the mining industry be the most important in Latin America, it currently holds place 14 in international economy^{55,56,57}.

The change and increase that this sector of economy has had deserves a careful inquiry on its consequences; in 2010 Colombian coal mining in the world represented 0.8% (6.668 million tons) 826.000 million tons of the world coal reserves and it has the largest reserves in Latin America. Between 1990 and 2009 the country doubled its participation in coal world production, moving from 0,45% to 1%, in South and Central America that is of 70% in 1990 to 87% in 2010 exporting US\$ 6,015 million in coal, in 2013 the production was of 62.659.407,67 tons, which meant a 20,305 increase that is an increase of 3.734.717,91 tons.

The findings of a sample of workers of 232 underground coal mine workers and 18 companies of the same productive sector of the department of Boyacá were described, all affiliated to the Social Security on Occupational Risks General System with the governmental insurer POSITIVA, the greatest amount of workers was from the town of Samacá 45,7%, they were concentrated in small companies 73,3%, the significant age group was the one between 40-49.9 years old, the participants were men, the most reported socioeconomic level was two with 51,3% the most frequent marital status was married 43,10%, the educational level of the workers was complete primary 37,5%. It was shown that fulfillment is barely present with a level of scarcely over 50% of the legal system. As for risk identification and knowledge, the association between risk recognized by workers and reported by the company physical noise was significant 16,2% and work on hot 8,88%. The association between use of personal protection elements by the workers and the ones provided by the company respiratory protection with cartridge was significant 75,80%, and hearing protection of insertion type 78,00%, and hard cup 80,40%.

This has caused an increase of 42% of jobs generated by the sector from 2005 to 2011, moving from 175 thousand to 249 thousand, thus in December of the past year POSITIVA Occupational Risks Administrator had an affiliation of 33000 workers of the mining activity, of which 90% corresponded to formal mining, nevertheless it has been considered that about 60.000 to 90.000 workers are connected in the inner part of the country, which meant that about 27.000 to 61.000 workers are not insured in occupational health, it is estimated that this sector generates around 4.000 to 8.000 jobs in Boyacá, according to FEDESARROLLO, 2011. Most importantly, this situation will go on at least for 30 more years, which implies questioning the management carried out by the employers and the State on implementing follow ups and controls in terms of safety and occupational health in underground coal mining.^{60,61,62,63,64,65}

This development dynamics has made the State have a specific regulation frame for mining safety, which governs the different aspects related to the operation conditions of mining exploitation in the country. Starting by Act 1382 of 201 that modified Act 685 of 2001 or the Mining Code, Decree 035 of 1994 on the provisions on the matter of Mining Safety, Decree 2222 of 1993 or the Safety Regulations on open pit mining labors and Decree 1335 of 1987 or the Safety Regulations on Underground labors⁶⁶.

Nevertheless the result of the study showed that fulfillment of legal dispositions is scarcely above 50%. Demonstrating that in terms of characterization of activities of the preventive medicine and work, hygiene and industrial safety subprograms implemented by the companies, that in Boyaca were classified as big have a better legal fulfillment than those of medium and small size, the results are similar to those of a study carried out by FEDESARROLLO 2011, these are explained due to the fact that they don't want to put their investment nor their patrimony at risk.

While medium and small size companies had an uneven behavior, which is in accordance with the findings of the same study, because in spite of the intentions of being legal, the activity is characterized by being a means of immediate income, a weakness that does not allow a future projection, with an aggravating factor that there is no clear vision of the business; it is known that this would imply enforcement and high investment costs (in human, physical, technological and economic resources). All this results in informal jobs where the denominator continues to be lack of social security, no affiliation to occupational risks, no incorporation to the pension system, which brings as a consequence no protection of the worker and no attention in case of accidents.

With respect to the Safety and Health at Work System Management component big companies are highlighted for their fulfillment with 61,67%, followed by medium size companies with 45,00%. In preventive and occupational medicine the small companies had less fulfillment record, for industrial hygiene and basic sanitation less fulfillment was found in medium size companies and the industrial safety component had less fulfillment in small companies.

As for identification and knowledge of risk by the workers and the ones reported by the employers the association of risk recognized by the workers and the ones reported by the company in physical risk noise was significant with 16,2% and work on hot with 8,88%. The association between use of personal protection elements by the workers and the ones provided by the company respiratory protection with cartridge was significant with 75,80% and hearing protection of the insertion type 78,00%, with hard cup 80,40%, rope with lampholder 77,20%, leather boots 36,70% and life safety rope 78,50%.

The main problem is that 44% of the six thousand mines that operate in the country to February 2012 do not have a license from the State to operate, they are illegal, which makes it very likely that they do not comply with the necessary safety norms for this kind of work, circumvent control systems such as environmental license, payment of taxes and royalties is avoided, it negatively affects protected ecosystems in an irreversible and irreparable way, making the implementation of governmental programs to enhance the working conditions and quality of life or mine workers difficult, hindering the access of workers to benefits such as labor and occupational safety^{66,67,68,69}. At the same time the Ministry of Mining and Energy does not have enough number of safety inspectors to make the mandatory controls, coal mining has grown slightly faster than the GDP of the mining sector and total GDP; Boyacá represents 3,1%. According to figures reported by the Center for Economic Studies of FEDESARROLLO 2012 and the Office of the Peoples Ombudsman of Colombia.⁷⁰

Information on the job possibilities of coal miners in underground mines of the country and generating employment is limited. In this sense characterizing the Colombian mining sector has a vital importance from an economic, social and political standpoint. The industrial safety practices in coal mining must be formalized and strengthened to avoid the precarious working conditions that are currently present; this will allow moving forward in the fulfillment of legal regulations and insurance of the workers.

Not paying tributary obligations, weak supervision among others, encourage the breach of valid obligations and labor regulations by a few that ends up affecting everyone's reputation.

Mining in the department of Boyacá is a means of immediate survival, in which the greatest expense of the miners is on alcohol/beer. The future is not seen it is just lived and no better working conditions are aimed at, which can be explained by the incipient academic training and lack of opportunities, the workers move around the mines of the region, searching for the highest bidder, there is no savings culture, nor health forethought and the topic of work risks causes no concern.

Biases on information and of memory were taken into account thus in the first individual and company structured questionnaires were created with closed questions, in the second the questions were designed in such a way that reference to times was less than 6 months.

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The authors declare not having any conflict of interests.

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