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The Reaction of Airways of Employees Working in the Environments Polluted with Heavy Metals in Mine Kosovo

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Abstract

This paper is studied the respiratory function as a result of the impact of air pollution in the environment of the sector of exploitation of heavy minerals such Pb, Zn, Au, Ag, Bi, Cd, PM in the mines of Trepça, Kosovo. Lung function parameters are determined by Body plethysmography. Airway resistance (Raw) was recorded and Intra-Thoracic Gas Volume (ITGV) was measured and specific resistance (SRaw) and airway specific conductance (SGaw) were calculated. The research was done in two groups, the control group and the experimental one. The control group consisted of 24 healthy people, while the experimental one is made up of 52 mining workers for the exploitation of minerals in the Trepçamine, Kosovo. The results obtained from this research indicate that the mean value of specific resistance (SRaw) is significantly higher in the experimental group ($p<0.01$), compared to the control group ($p>0.1$). Also, in this study it was confirmed that smoking favors the negative effects of air contamination in the mineral exploitation sector, the changes are significant ($p<0.01$). Respiratory system parameters of the control group and the experimental group were measured before and after bronchoprovocation with histamine-aerosol (1 mg/ml). The differences between these two groups after provocation were statistically significant ($p<0.01$). Respiratory changes from air pollution with noxae in mines where metals are mined, it takes a long time for changes in respiratory function to appear. Therefore, exposure of workers to these conditions poses a risk to their health, causing bronchial reactivity, bronchial asthma or, obstructive pulmonary syndrome.

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1. Introduction

Numerous studies show that obstructive pulmonary disease, especially chronic obstructive bronchitis, is not only a geriatric problem but mainly a problem of the "large mining basin", industrial complexes, densely populated urban areas, and people of all ages[1,2]. But it should be noted that over time, the mortality rate due to obstructive pulmonary disease has a constant tendency to increase. Based on previous studies, it can be said that the symptom complex "emphysema-chronic obstructive bronchitis" is a very serious socio-medical problem, due to the high frequency of occurrence, duration of the disease, serious disability, and often fatal outcome[3,4].

This issue has been known for a long time, it has not yet been given the place it deserves, especially for the population working in the industry as well as for densely populated countries. Lost working time due to Chronic Obstructive Pulmonary Disease (COPD) is twice as high as in other diseases. Disability at work is also twice as high in obstructive airway diseases and very often remains as a permanent disability[5].

Chronic obstructive bronchitis in Western Europe is one of the most common diseases and is the leading cause of incapacity as well as permanent disability. Authors from the United Kingdom, Finland, Sweden, and Russia also emphasize the great importance of these diseases, while statistics in the US show that chronic obstructive pulmonary disease as a cause of disability ranks second, after heart disease[6].

One of the important features of patients with obstructive bronchitis is the permanent presence of an inflammatory process in the respiratory tract. To a greater or lesser extent, the inflammatory syndrome is present throughout the organism. Over time, hyper responsiveness of the bronchial system occurs, which is a consequence of the action of various irritants and certain spasmodic substances. This increased bronchial reactivity is manifested by reversible constriction, non-uniform ventilation distribution, a discrepancy in ventilation and perfusion processes, and a change in arterial blood gas concentrations. Disorder of the bronchial response in the form of airway hypersensitivity due to the action of various bronchoconstriction substances depends on many factors[7,8].

Since the subject of the study is workers with a multi-year period of pollutant absorption, it is expected that significant changes will be caused in the tracheobronchial trunk.

The purpose of the research is not only to ascertain the changes in the respiratory tract of the workers of the Trepça mine-Kosovo but also to analyze the nature of the changes and the possible mechanisms of their manifestation. Since it is known that any tissue damage generates an inflammatory response, the parameters of the inflammatory response will be analyzed to assess the possible and immediate impact of the inflammatory response and changes in the tracheobronchial trunk as well as in the respiratory tract in general.

2. Materials and Methods

This study project was approved by the Ethics Committee of the Faculty of Medicine in Prishtina.

2.1 Study Design

The study was conducted on 76 patients with reversible airway obstruction. The selection of patients was made based on anamnestic data, clinical research, and functional examinations of the respiratory system determined by body plethysmography. The changes are shown in Table 1, 2 and Diagram 1.

2.2 Study Procedures

The examinees were familiar with the manner of functional analysis of the lungs. The purpose of the examination has already been explained to each worker. The lung function at rest is determined, which consists of measuring airway resistance (Raw) and In-Trathoracic Gas Volume (ITGV) with body plethysmography which is a very sensitive and accurate technique in investigating the phenomena that influence bronchial reactivity. From the obtained values, the specific resistance (SRaw) and the specific conductivity (SGaw) of the airways were calculated:

SRaw = Raw x ITGV; SGaw = 1/SRaw

Our study has focused on research on bronchial reactivity and chronic diseases obstructive pulmonary disease by applying the questionnaire for chronic respiratory diseases (MRC)[9]. The research in working environments during exposure to different nocturnes shows large differences in the increased prevalence of bronchial reactivity and obstructive pulmonary diseases, such as different habits, smoking, working conditions,

workplaces, etc. In smokers and non-smokers the plethysmographic values of the workers examined show a tendency to increase with age and the duration of exposure to harmful noxa in the workplace. It is important to note that there are statistically significant differences between smokers and non-smokers. There are also statistically significant differences of these values with the values of persons suffering from chronic obstructive bronchitis and persons without chronic obstructive bronchitis which reduces the value of the MRC questionnaire.

The inclusion criterion in the research was performed on workers who have worked for at least 5 consecutive years in the jobs in the Trepca mine-Kosovo, or cumulatively for at least 10 years in the last 20 years.

The exclusion criteria from the study did not include workers who had any other lung disease that could have an impact on parameters during body plethysmography measurements.

The research was conducted in two working groups: The control group includes 24 healthy students that do not work in the mining areas. The experimental group has included 52 workers, with permanent work in the mine for the extraction of heavy minerals in Trepca, Kosovo.

In the control group and the experimental group, we performed the bronchoprovocation test with a bronchoconstrictor agent, such as histamine-aerosol (1 mg/ml)[10].

Afterward, plethysmography was performed to measure the air volumes in the thorax. Plethysmography consists of a plastic booth into which enters the person who will undergo the measurements. He blows in a turbine, which like spirometry records volumes and air flows. In this way, we record the pressure-pressure curve as well as the pressure-air flow curve.

In case of chronic changes in the respiratory system; bronchial hyper responsiveness, bronchial asthma, or COPD, people were appropriately treated with the following medicines: adrenergic bronchodilator or anticholinergic substance or methylxanthines[11-13].

Corticosteroids, antihistamines, antileukotrienes have been used as anti-inflammatory drugs[14-16]. Since the medical treatment of these diseases is limited, therefore the only way to avoid chronic respiratory disorders is to take preventive measures[17].

2.3 Statistical Analysis

In this study, we are dealing with the difference between the two research groups. On this basis, we have used the t-test as a differentiating mechanism concerning the level of significance between the comparative groups. In the control group and the experimental group, we have two series of values of plethysmography parameters, which are obtained as a result of measurements before and after the bronchoprovocation test with histamine (1mg/ml).

Direct or indirect airway obstruction indicators are presented with mean value (X), standard error (SEM) and Standard Deviation (SD) with the One Way ANOVA variance analysis test. The parameters are summarized in the MS-EXCEL program. The obtained results were tested with the help of the Student t-test, to ascertain the significant differences between the experimental group and the control group.

3. Results

In healthy individuals, bronchial reactivity of the respiratory system does not appear and can be used as a

Table 1. General features of the surveyed persons

Group	N	Age (years)	Height (cm)	Weight (kg)	VC (L)	FEV_1 (L)
Control	24	23.3± 0.7	172±0.27	67.5±1.8	3.77±0.11	3.66±0.11
Experimental	52	47.23±0.02	176±0.48	76±1.23	3.7±0.16	3.4±0.43
One Way ANOVA	76	p<0.01	p>0.1	p>0.1	p>0.1	p>0.1

Control group n = 24, X ± SEM; Experimental group n = 52, X ± SEM

control group to assess the condition of the experimental group (Tables 1&2 and Diagram 1).

The results indicate that we have no significant changes in healthy individuals, prior and after bronchoprovocation with histamine-aerosol (1mg/ml), ($p>0.1$). Specific resistance (SRaw), and specific conductance (SGaw), was calculated for the control group and the experimental group, and this indicates that we found a significant difference between these two groups ($p<0.01$). The results indicate the presence of emphasized bronchial reactivity in individuals of the experimental group. The parameters, SRaw and SGaw, have been analyzed and presented graphically in Figures 1, 2 and 3 for both groups.

In the experimental group, the reduction of transfer factor (DLCO) in practice presents difficulties in the circulation of gases through the alveolo-capillary

Table 2. Body-plethysmography features of the people involved in this study

Group	N	Raw (kPa×s/L)	ITGV (L)	SRaw (kPa×s)	SGaw (kPa×s)
Control	24	0.16 ± 0.3	3.25 ± 0.9	0.52 ± 0.04	1.92 ± 0.19
Experimental	52	1.18 ± 0.9	3.5 ± 0.7	4.13 ± 1.23	0.24 ± 0.13
One Way ANOVA	76	$p<0.01$	$p>0.1$	$p<0.01$	$p<0.01$

Raw (kPa × S/L); ITGV (L); SRaw = Raw×ITGV; SGaw=1/SRaw

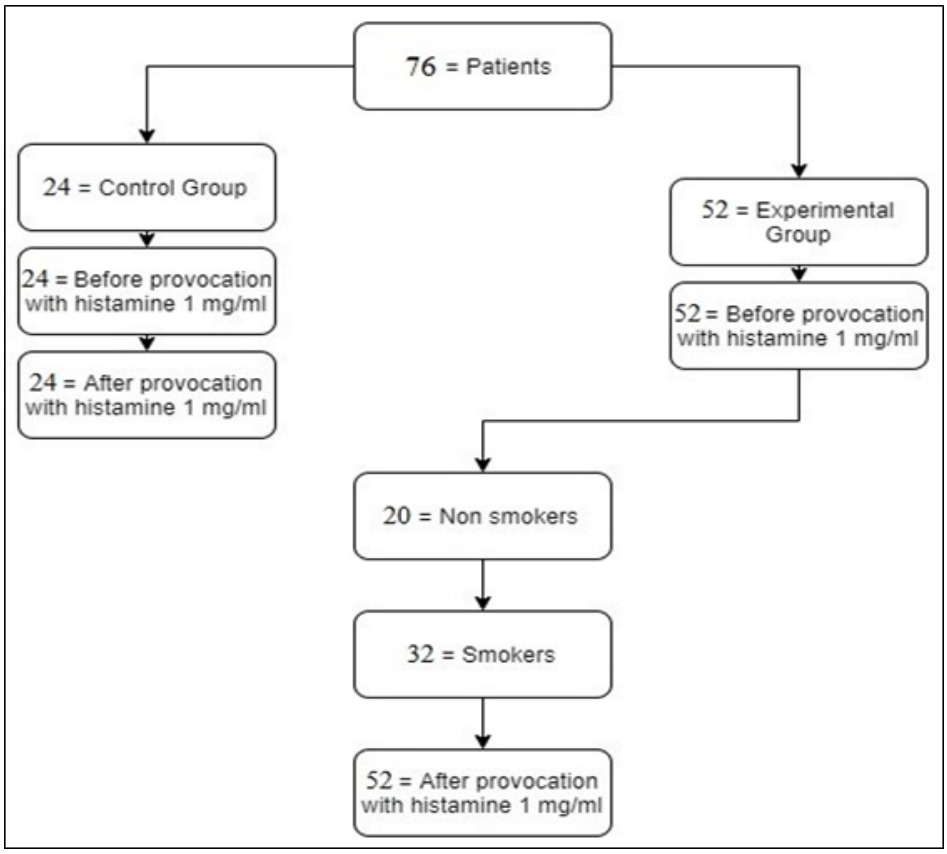


Diagram 1. Frequency of workers participating in the research of the control and experimental group.

membrane, in comparison to the control group, the changes are statistically significant ($p<0.05$) (Figure 4).

Research in heavy metal extraction facilities shows a pronounced impact on causing bronchial reactivity and chronic obstructive pulmonary disease; So in this regard duration of exposure (over 20 years), climatic conditions in the workplace, different habits, smoking, etc. also affect.

It is important to note that there are statistically significant differences between nonsmokers and smokers ($p<0.01$). There are also changes in the values of people suffering from chronic obstructive bronchitis and people without chronic obstructive bronchitis, which reduces the value of the questionnaire.

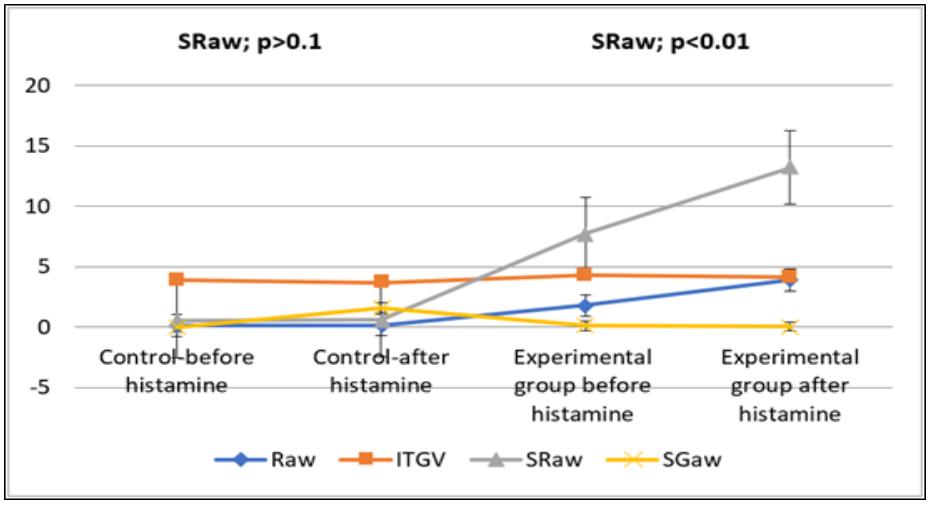


Figure 1. Control and experimental group prior and after provocation with histamine–aerosol 1mg/ml. Comparison of values of SRaw and SGaw in between the control group, n=24; X±SEM) and the experimental group. (n=52; X±SEM).

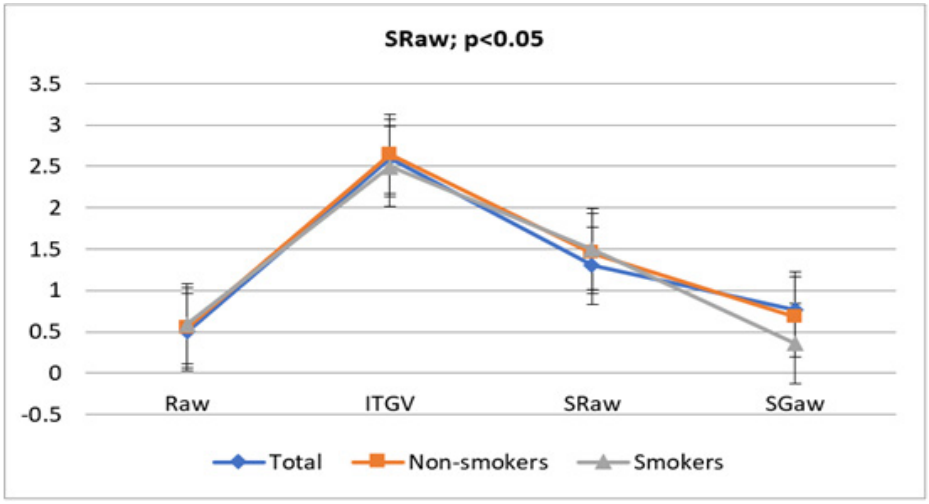


Figure 2. The subject of the research as per the category of non-smokers and smokers (Prior provocation with histamine-aerosol). Comparison of the SRaw and SGaw values in between non-smokers and smokers; (n=52; X±SEM).

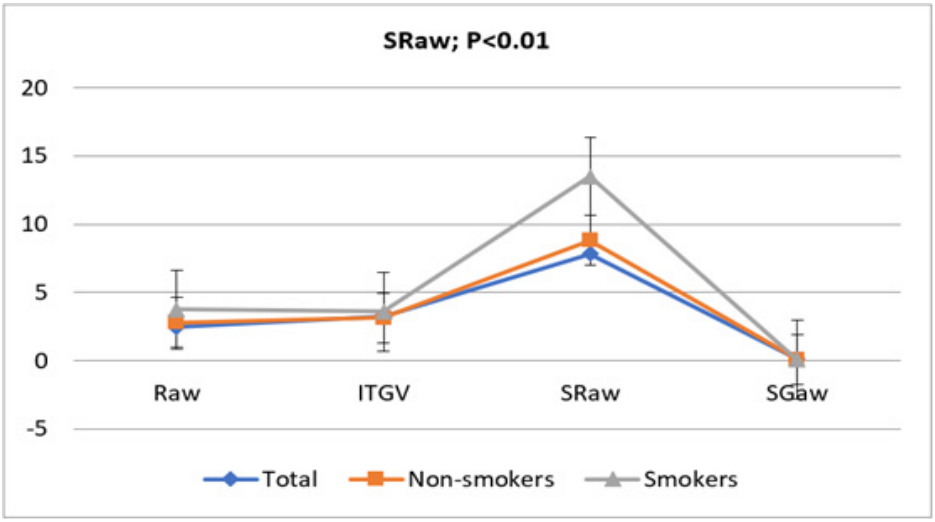


Figure 3. The subject of the research is according to non-smoking and smoking categories (After provocation with histamine-aerosol 1 mg/ml). Comparison of SRaw and SGaw values between non-smokers and smokers; (n=52; X ± SEM).

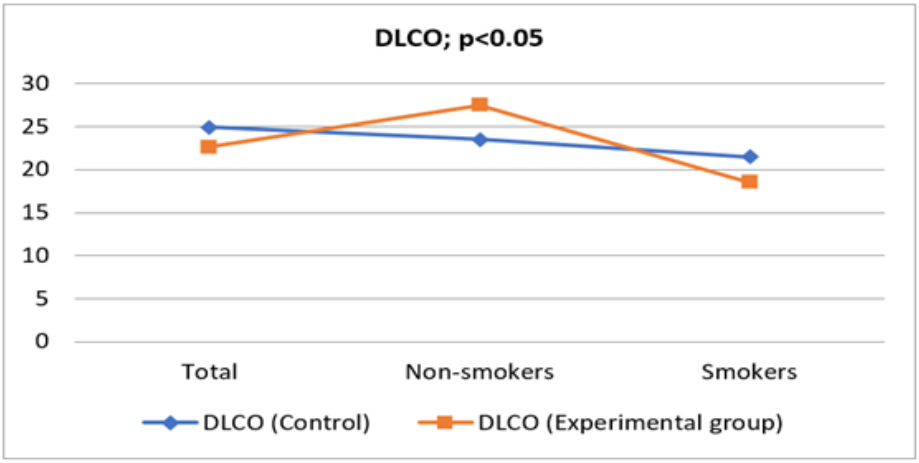


Figure 4. Transfer factor (DLCO) at the control group and the experimental group expressed (mmol/sec/1kPa). (n=76; X±SEM).

These studies undoubtedly indicate that long-term exposure to ore mining sites has a detrimental effect on the respiratory system and that particulate matter released into the air during metal mining also increases the release of chemical mediators (leukotrienes, prostaglandins, prostacyclin, histamine, serotonin, bradykinin) and other inflammatory factors in the trachea-bronchial system, which is manifested by increased bronchial reactivity reduction transfer factor (DLCO) for carbon monoxide, which in the experimental group compared with the control group is significant ($p<0.05$)[18].

4. Discussion

Disability as a socio-medical phenomenon, in a way, reflects not only the degree of success of human adaptation at work and life after illness and injury but also the conditions in which an employee can exercise

the right to protection of the disability. Evaluation of the ability to work in patients with respiratory diseases is undoubtedly a very important and difficult task for physicians assessing temporary or permanent incapacity for work. The importance of this problem can be best seen from the number of requests submitted each year to disability commissions to assess disability and reduced ability to work as a result of exposure to harmful noxae[19]. In recent decades, we have faced an increasing incidence of chronic respiratory diseases in the pathology of the population - not only of our country but of the general population on a global scale, especially in large cities[19].

Many years of worker exposure to various noxae (dust, gases, and vapors) significantly alter bronchial reactivity and affect plethysmography and other respiratory function parameters such as transfer factor (DLCO) and acid-base balance of gases of respiration in capillary blood increases the concentration of histamine in saliva. These changes are more significant in smokers than in non-smokers[20].

This large amount of noxae released has an irritating effect on the respiratory system and certainly plays an important role in the development of chronic obstructive bronchitis. These agents can cause effects on the upper respiratory tract, but they can also cause pulmonary edema or glottis. This difficult clinical picture (according to Hunter) is still rare because due to protective reflexes, the worker is forced to leave the closed environment immediately. Sudden exposure to very high concentrations can cause respiratory arrest, severe respiratory damage, and even death[21].

76 workers of the heavy metal mine in the Trepça ore in Kosovo are included in the research. All patients underwent a bronchoprovocation test with histamine aerosol (1mg/ml), which confirmed the presence of bronchial hyper responsiveness of the experimental group (mine workers). This confirms the diagnosis of bronchial hyper responsiveness and the emergence of the need for the use of bronchodilator medicines.

With the analysis of the function of the respiratory system without provocation with histamine, we have preserved the ventilatory values of both groups (control and experimental). After provocation with histamine, pronounced hyperm responsiveness of the experimental group (of workers who worked in mines for the exploitation of ores) was caused. This is confirmed by the increase of specific resistance (SRaw) and decrease of specific conductance (SGaw) of airways ($p<0.01$) and the reduction of carbon monoxide transfer factor (DLCO), the changes of the experimental group compared to the control group are significant ($p<0.05$)[22,23]. At the beginning of the research, both groups had parameters within the limits of normal values. Some studies show that there is a direct correlation of bronchial hyper responsiveness to histamine or methacholine with the variables SRaw and SGaw[24,25]. In patients of the experimental group, we find a positive bronchoprovocation test, which means that bronchial hyper responsiveness is caused compared to groups of healthy people where the bronchoprovocation test is negative. This finding excludes the diagnosis of bronchial hyper responsiveness and we have no changes in the parameters of respiratory function ($p> 0.1$).

The modern assessment of workability is an assessment of the relationship that exists between the anatomical and functional features of the working person, on the one hand, and the requirements of the job, or place of work, on the other. It is an altered condition and must be constantly monitored throughout one's life at work.

Recognition of inflammation as the main generator of changes in the respiratory tract, suggests the need for a pharmacotherapeutic approach, which should be as etiological as possible. Pharmacological preparations should be technologically prepared in such a way that they are easily applied in the form of aerosols for the respiratory tract[26].

Many studies show that bronchial hyper responsiveness, even after the application of therapy, does not return to normal. The number of sputum eosinophils is increased in these patients[27,28].

Fujimura et al. have proven that patients treated with bronchodilator medicines alone do not have the appropriate effect, but only aggravation can be expected after use for a longer time, respectively this therapy is also a precursor to the classic development of bronchial asthma[29]. Timely application of anti-inflammatory drugs e.g., Inhalation of corticosteroids significantly reduces bronchial hyper responsiveness and thus reduces the risk of developing classic bronchial asthma.

Given the possible improvements in the use of modern technological processes, it is unlikely for a global and comprehensive solution to environmental problems shortly. Global change in the world, and this field, offers the opportunity to significantly improve the quality of life, as well as improve environmental conditions. For the past two centuries, the issue of environmental

pollution has become increasingly challenging over time. Thus, the protection of the environment has become a necessity of the whole civilization and each individual. Every investiture must plan the technological processes, from the beginning to solve the problem of "possible emissions of harmful terminal or intermediate products of the technological process in the environment". For several decades, the problem of pollutant emissions into the environment has been solved by installing certain filters. However, filters generally do not offer 100% protection[30].

The process of developing changes is dynamic, and in the function is the duration of exposure but also the constitutional predisposition for each person separately, whilst much depends on the habit of smoking. However, preventive action is more effective (effective reduction of environmental pollution by using technical means of "air purifiers", "aspirators", "adsorbents", "sealing of technological processes". Permanent air monitoring is a prerequisite for taking measures. On the other hand, permanent monitoring of renal function parameters with plethysmography, spirometry, bronchoconstrictor tests with constrictive substances, measurement of bronchial reactivity, changes in transfer factor, respiratory gases, extraction and analysis of substances that can be exploited, provide time to take therapeutic measures to treat the condition, i.e. other measures which are as necessary preventive to protect the health of workers in the workplace[31,32].

For this reason, it is necessary to include an expanded number of experts of different profiles, in the fields of pharmacology, toxicology, ecology, pathophysiology, clinical biochemistry, histopathology, immunology, pharmaceutical technology (for the preparation of adequate forms of the medicines for the treatment of diseases of the respiratory tract), when it comes to protecting the health of workers who work all their lives in polluted environments[33,34].

Although the above options offer economically acceptable solutions for a longer time, mining technology is one of the areas that are not expected to be solved in the foreseeable future, so it will still be necessary to ascertain the harmful effects of the environment where one works in such a microenvironment, to address the consequences caused to the respiratory system.

5. Conclusion

Based on the research done, and the results obtained, it can be concluded that permanent monitoring of the condition of the respiratory system and early detection of bronchial hyperactivity is more than necessary. In workers, it is necessary to perform bronchoprotective tests with histamine or methacholine, to detect hyper-reactors in time and to start treatment as soon as possible. Patients with hyper responsiveness indicate a predisposition for the development of long-term changes in the respiratory tract, the development of bronchial asthma and COPD, therefore the health of these workers should be treated with high priority as the category of individuals at high risk. This research clearly shows that exposure to environments where ores are exploited causes bronchial hyper responsiveness with statistical changes ($p<0.01$), which is manifested by a reduction of carbon monoxide transfer factor (DLCO), the changes are significant ($p<0.05$) at the group of exposed workers in comparison with the control group ($p>0.1$).

6. Author Contributions

AB and SM conducted the literature search and determined studies for exclusion and inclusion. PI and AI extracted data from the studies included, performed the meta-analysis, and drafted the manuscript. HI conceived the idea for the study, designed the study, and critically revised the manuscript for content. All authors contributed to the data analysis, drafting and revising the article, and gave their final approval to the version to be published, and agreed to be accountable for all aspects of the work.

7. Disclosure

No conflict of interest was declared by the authors.

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