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Prevalence and Predictors of Respiratory Symptoms Among Kazakhstani Coal Miners

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by

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Acknowledgments

We would like to thank all of the coal miners of Karaganda who participated in the study.

Background Underground coal mining has been a crucial part of Kazakhstan's economy for the last 30 years, yet little is known about the burden of respiratory disease and trauma among Kazakhstan miners.

Methods A cross-sectional survey among a random sample of working miners was conducted; demographic, work, and health information were collected using a standardized questionnaire.

Results

In a survey of miners, 30.47% reported respiratory symptoms, primarily shortness of breath, and chronic bronchitis emerged as the most common respiratory illness, underscoring the health risks from prolonged coal dust exposure. The study also found a strong association between miners' age and tenure and the prevalence of respiratory conditions, indicating that longer exposure in older miners significantly raises health risks. In addition, it was found that workplace trauma had a notable association with respiratory symptoms and traumas. This implies that traumatic incidents at work could worsen already existing respiratory problems. Strikingly, the correlation between smoking and respiratory illnesses in miners was insignificant which hints towards the likelihood of occupational dangers playing a more crucial part than smoking in causing breathing issues within this category.

Conclusions

The resulting study was the first in Kazakhstan's literature to report on respiratory symptoms in this population; likely underestimation of disease rates due to selection and measurement biases was demonstrated. Efforts in better occupational safety practices, enhanced health monitoring, and stricter regulatory oversight should continue to reduce respiratory illness among Kazakhstani coal miners.

Keywords: Kazakhstan, coal miners, respiratory symptoms, occupational health predictors.

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Abbreviation	Definition
CWP	Coal workers' pneumoconiosis
YPLL	Years of Potential Life Lost
CI	Confidence interval
HWSE	Healthy worker survivor effect
PPE	Personal protective equipment

Introduction

Coal Production

Despite international initiatives towards green energy sources such as natural gas, coal remains the second largest energy source worldwide. In 2010, approximately eight billion tons of coal were produced (US Department of Energy, 2010). Projections from the US Department of Energy anticipate an annual increase in global consumption by 1.8% between 2010 and 2040. As noted by GlobalData (Kgi-Admin,2023), Kazakhstan emerged as the world's tenth-largest coal producer in 2022 with major production regions being Karaganda, Ekibastuz, and Torgay basins. Their current total export accounts for merely a quarter (27%) hence plans are underway to boost it up to reach around 40% by 2040. This will largely be driven by demands from Russia, the European Union, and China.

As of now, thirty-three companies are involved in coal mining operations across Kazakhstan. These include 28 domestically owned companies, five foreign entities, and one joint venture (Energy Charter Secretariat, 2013). Many of these companies still rely on outdated Soviet-era technology and management practices, which significantly hinder the industry's growth. Moreover, the shortage of funding for the mining industry in Kazakhstan has hindered the exportation of mining equipment. Despite a stream of foreign investors embarking on exploration and development projects since the mid-1990s, only a handful have persevered as most have encountered setbacks such as non-transparency, inadequate financial incentives, favoritism towards local investors alongside an inefficient bureaucracy, and ambiguous laws related to land tenure (Kazakhstan - Mining Equipment and Services 2022). As a result of these events, coal mining became one of the most dangerous occupations characterized by high mortality rates.

In the years since Kazakhstan announced independence, the number of tragedies in the national coal industry has been significant. 183 miners have lost their lives from methane releases and explosions alone. Additionally, fatalities have occurred because of cave-ins, mine fires, and various accidents. One of the particularly devastating examples was the explosion at the Kostenko mine in the Karaganda region on October 28, 2023. As a result, 42 people died, making it the most massive accident in the entire history of the Kazakh coal industry.

Respiratory Diseases from Coal Mine Dust

Inhalation of coal mine dust presents a significant occupational hazard for coal miners globally. Exposure to coal mine dust has been consistently linked to various respiratory conditions, including pneumoconiosis, lung function impairment, and an increased frequency of respiratory symptoms (NIOSH, 1995).

Pneumoconiosis, a lung disease common among miners, develops from long-term exposure to airborne dust containing tiny particles that deeply penetrate lung tissue (Cohen et al., 2008). Alarmingly, the occurrence and severity of classic coal workers' pneumoconiosis (CWP) and silicosis have increased dramatically since the early 2000s (Petsonk EL et al., 2013).

Globally, the rate of CWP has fluctuated significantly over the decades. It fell from 23.33% before 1970 to 6.00% in the 1980s but rose again in the 1990s before decreasing to 2.29% by 2020 (Liu et al., 2022). The highest instances of CWP in the last 30 years were observed in Europe, China, and the USA.

In developed countries like the UK and the US, the prevalence of CWP has generally been declining thanks to improved safety regulations and management programs. For example, in the UK, the rate dropped dramatically from 12.1% in the early 1960s to just 0.2%

by the mid-1990s. The US saw a decline from 6.5% in the 1970s to 2.1% in the 1990s. However, these reductions were not maintained and the prevalence went up in the following decades (Nlandu et al., 2012; Laney and Attfield, 2010). This resurgence may have been caused by longer working hours, increased exposure to silica dust, and greater workloads.

Despite decades of prevention efforts, CWP remains a significant public health issue worldwide. In countries where coal is the primary energy source, millions of workers are exposed to coal dust every day (Xi Z JM et al., 2014; Mukherjee AK et al., 2005). China, the world's largest coal producer and consumer for the last two decades, has significant prevalence rates of respiratory diseases among its coal miners the pooled total prevalence of CWP was 6.02%, and the pooled rate of CWP patients combined with tuberculosis was 10.82%. This shows that over 10% of China's coal miners suffer from a group of lung diseases caused by the inhalation of dust, with coal dust being a major contributor (Mo et al., 2014). India, another major coal-producing country, also faces significant challenges with respiratory diseases among its coal miners, with prevalence rates ranging from 5% to 9% (Laney and Weissman, 2014).

Moreover, miners are at increased risk of mortality from lung cancer, particularly with prolonged exposure to diesel engine exhaust (CDC - Mining Topic - Respiratory Diseases - NIOSH, 2022). Studies from the United States and the United Kingdom have shown a clear relationship between cumulative coal-mine dust exposure and chronic bronchitis (Henneberger and Attfield, 1997). The impact of respiratory diseases on premature mortality, as measured by Years of Potential Life Lost (YPLL), mirrors the prevalence trends of CWP. While there was a decline from the 1970s to 2000, in recent years there has been a worrying increase (data updated from 2009 MMWR). For instance, in 2010, mortality from CWP resulted in an average of 8.2 YPLL among coal miners.

Despite the significant workforce, such as the over 150,000 coal miners in Kazakhstan, there remains a notable lack of information regarding the burden of respiratory diseases within this population (https://www.energycharter.org/fileadmin/DocumentsMedia/Events/20100709-6RECA_S1_JTuleubaev_ru.pdf , accessed March 01, 2024). While studies from other regions have documented the prevalence of respiratory diseases among coal miners, there is limited research focused on the unique context of Kazakhstan, including its distinct coal mining practices, environmental conditions, and healthcare infrastructure. Existing studies don't look closely enough at how common respiratory problems are among coal miners in Kazakhstan or what might cause them. This makes it hard to make specific plans to protect their health at work. By addressing this gap, this study aims to provide valuable insights into the respiratory health status of Kazakhstani coal miners and identify factors contributing to respiratory symptoms, thus informing evidence-based interventions to safeguard the health and well-being of this vulnerable occupational group.

Methods

Study Location

The research was conducted in Karaganda, a city at the core of Kazakhstan's coal-mining sector. Our focus was on a specific mine representative of the typical mining operations found in the area. This mine, an anthracite coal mine, is noted for its deep-shaft setup, extending 500 to 600 meters beneath the surface.

Study Design and Sampling Strategy

The study used a cross-sectional survey design and was conducted in March 2024. The participants eligible for the study were male miners aged 18 and older who were actively working in underground coal mining at the time of the study.

Then the sample was categorized into age tertiles, creating three groups: those aged 20–30, 40–50, and 50–66 years. This division was designed to explore potential age-related differences in experiences and health impacts.

The sampling approach used was convenience sampling, meaning individuals were selected based on their availability and willingness to participate. Both the management of the mining company and the research team were involved in distributing the questionnaire to those who met the study criteria.

Data Collection Tools and Study Variables

For this study, data collection was primarily conducted through a questionnaire, detailed in Appendix 1. This questionnaire consisted of 27 questions addressing various topics including demographics, respiratory symptoms and illnesses, work histories, tobacco usage, and instances of traumatism.

The survey design was influenced by established instruments from the American Thoracic Society and the U.S. National Institute for Occupational Safety and Health (NIOSH). These models are well-regarded for their thorough approach to assessing respiratory health and occupational safety, making them ideal frameworks for gathering relevant and reliable data in the context of coal mining. To facilitate participation and ensure accurate responses across diverse linguistic backgrounds, the questionnaire was translated into both Russian and Kazakh languages. This multilingual approach aimed to enhance comprehension among participants and minimize response errors stemming from language barriers or misinterpretation of

terms. A total of 120 participants completed the survey and were then evaluated according to the eligibility criteria.

Human Subjects' Protection

Before the involvement in the study, all participants were provided detailed information about the study objectives, procedures, potential risks, and benefits. Subsequently, participants were required to provide their informed consent. They were informed that their participation was entirely voluntary and that they had the right to withdraw from the study at any time. The study was approved by Nazarbayev University, Institutional Review Ethics (protocol #2024Feb#03).

Data analysis

STATA 17 statistical software was employed to process and analyze the collected data. As of March 2024, the mining company under study employed 9,419 coal miners. Among these, 120 individuals participated in the study, representing approximately 1.27% of the total workforce. However, due to missing data in some responses, 15 respondents were excluded from the analysis. This exclusion was necessary to maintain the quality and accuracy of the dataset, resulting in a final sample size of 105 participants for analysis.

Descriptive statistics were used to present the main findings on socio-demographic characteristics such as age, tenure, and smoking status. Main respiratory symptoms were also summarized to provide information about the prevalence of symptoms and occupational health. Descriptive statistics allowed us to identify the main patterns observed in samples and determine appropriate interventions. The

association between independent variables and the predicted outcome was assessed using Fisher's exact test, as it allows us to perform tests given the small sample size.

Because of the cross-sectional study design, Poisson regression with robust variances and reporting rate ratios was used to effectively handle the specific challenges posed by count data and the study design (Table 5). Poisson regression is ideal for modeling event counts like illnesses, providing direct insights into the rates at which these events occur relative to various predictors such as age and tenure. The reporting rate ratios derived from Poisson regression offer a valuable interpretation of risk, indicating how much more or less likely an illness is to occur given certain exposures or characteristics. These rate ratios provide insights into the relationship between predictors and outcomes, facilitating a better understanding of the epidemiological factors influencing respiratory health among underground coal miners.

The implementation of robust variance estimates in the regression model addresses critical issues like overdispersion and data clustering, which are common in observational studies. This adjustment ensures that the statistical inference about the impact of different risk factors on respiratory illness rates remains valid and reliable, despite potential violations of the independence assumptions typically required by standard Poisson regression. Such robust analysis not only strengthens the reliability of the study findings but also enhances their applicability in informing policy decisions and targeted health interventions in the mining industry.

Definitions of Symptom and Illness

These are the definitions of symptoms and illness used in the study:

1. **Usual Cough:** This is a cough that persists most days for at least three consecutive months annually. People with this symptom might cough frequently, about 4–6 times daily, experience coughing first thing in the morning, or have bouts of coughing throughout the day.
2. **Usual Phlegm:** This involves producing phlegm on most days for three consecutive months or more each year. It may occur up to twice a day, particularly upon waking in the morning, or continue at various times throughout the day.
3. **Shortness of Breath (SOB):** This condition is noticeable when a person feels breathless while moving quickly on flat ground or walking up a slight incline. Additional signs include walking slower than peers due to shortness of breath, needing to stop for air after walking about 100 meters on flat ground or feeling too breathless to even leave the house.

Results

1. **Age Distribution**: Among the survey respondents, the largest group was those aged 36-50, making up 36.1% of the total. This was closely followed by the 20-35 age group, which accounted for 33.3%, and the 50-66 age group, representing 30.4%.
2. **Nationality Composition:** Russian coal miners formed the largest segment at 49.5%. Other nationalities, including Ukrainians, Tatars, Germans, and others, made up 27.62%, while Kazakh miners comprised 22.86% of the participants.
3. **Smoking Status:** Almost half of the miners (49.52%) reported they have never smoked, current smokers made up 30.48% of the participants, and former smokers – 25.71%.

Figure 1: Prevalence of Respiratory Symptoms

The data reveals that among the 105 participants surveyed, a significant portion, comprising 30.47%, reported experiencing respiratory symptoms indicative of potential lung issues. These symptoms serve as crucial indicators of respiratory health status and can significantly impact the quality of life and occupational performance of coal miners.

Among all our participants 30.47% are dealing with respiratory symptoms:

1. Most commonly, people experience **shortness of breath** (71.88% of cases), which makes it tough to carry out the physically demanding parts of their jobs in coal mining.

2. Additionally, about one in four mentioned they had a **cough with phlegm**, a sign that there might be irritation or inflammation in their respiratory tract, likely worsened by the dust and pollutants they're exposed to while working.

3. A smaller proportion (3%) reported **chest pain when breathing deeply**, indicating potential chest wall or respiratory muscle discomfort, which could be associated with respiratory conditions or occupational injuries.

Figure 2: Prevalence of Respiratory Illnesses

In addition to symptoms, a subset of participants (20.95%) had been diagnosed with respiratory illnesses, representing the prevalence of chronic respiratory conditions among coal miners in our study. These conditions are more severe and often need medical care to manage, pointing to the significant impact of mining work on lung health.

The breakdown of respiratory illnesses reported by participants includes:

- **Chronic bronchitis** was the most commonly diagnosed respiratory illness, affecting half of the participants with respiratory conditions.
- **Pneumonia**, accounting for 23% of reported respiratory illnesses, suggests acute respiratory infections that may be exacerbated by weakened respiratory defenses or underlying lung disease, common risks in coal miners.

- A notable proportion of participants (18%) reported **multiple concurrent lung illnesses**, indicating complex and potentially overlapping respiratory pathologies, further complicating diagnosis and management.
- Other respiratory conditions reported include **asthma** (9%), a chronic inflammatory disorder of the airways often exacerbated by environmental triggers.

The average age at which participants were diagnosed with respiratory illness was 37.4 years.

Association between participant characteristics and respiratory illnesses

We divided the participants into 4 categories:

1. Those who reported being diagnosed with respiratory diseases.
2. Those who has not been diagnosed but was experiencing respiratory symptoms.
3. 1st and 2nd group combined, making them the coal miners suffering from respiratory diseases and symptoms.
4. Those who did not report any respiratory symptoms or illnesses.

Based on Fisher's exact test, the analysis found:

1. **Smoking Status**: There was no clear statistical link between whether a person smoked and their respiratory health among the different groups.
2. **Ethnicity**: Similarly, the test found that a person's ethnic background did not significantly predict their respiratory health status among coal miners.
3. **Previous Exposure to Dusty Industries**: The analysis also revealed no significant results regarding participants' previous work in dusty environments like construction or manufacturing. This suggests that prior exposure to such environments might not have a considerable impact on respiratory health outcomes for these coal miners.

The additional analysis further reinforces the significance of age, tenure, and trauma exposure as predictors of respiratory health outcomes among coal miners:

1. **Age**: Across various subgroups, including diagnosed coal miners, those with respiratory symptoms and illnesses combined, and those reporting zero respiratory symptoms and illnesses, age emerged as a statistically significant predictor. This consistent finding underscores the role of age as a key determinant of respiratory health status among coal miners, with older individuals potentially facing greater risks of respiratory illnesses.
2. **Tenure**: Similarly, tenure (length of employment in the coal mining industry) was found to be a statistically significant predictor for these three groups. This suggests that longer tenure in the coal mining industry may be associated with an increased likelihood of developing respiratory illnesses.
3. **Years of Smoking**: The duration of smoking also was found to be a statistically significant predictor for specific groups.
4. **Trauma Exposure**: The analysis also revealed trauma exposure as a statistically significant predictor for the same three subgroups. This underscores the potential impact of occupational injuries or trauma on respiratory health outcomes among coal miners.

Discussion

Principal findings

Dust from mining can harm lung health and lead to serious diseases if not addressed promptly, posing a significant risk to miners. Despite the known dangers,

there's been a surprising lack of detailed research into how widespread respiratory issues are among coal miners in Kazakhstan.

This study aimed to fill that gap by examining how common respiratory diseases are among coal miners in Kazakhstan and what might increase their risk. The findings confirmed that these health issues are indeed prevalent; about 21% of the miners surveyed had been diagnosed respiratory diseases, and over 30% reported symptoms related to their respiratory system. These numbers are similar to findings from other coal mining areas like West Bengal, India, where about 44% of miners suffer from respiratory problems as reported by Prasad et al. (2019).

A recent systematic review by Akbar and Kallawicha (2024) also found that miners in Asia are far more likely to develop black lung disease compared to the global average – nearly four times as likely. The reasons for this include not only personal and behavioral factors but also aspects related to their jobs and how mines are managed.

The differences in prevalence observed across studies may be attributed to variations in medical standards, diagnosis procedures, data collection methods, and occupational factors across different countries. Nevertheless, it is evident that the prevalence of respiratory diseases among coal miners is notably high and our results are in concordance with other studies.

The higher rates of respiratory issues among miners in Kazakhstan might be linked to the nation's focus on boosting coal production, often overlooking the health impacts on the miners. Recent energy crises in various countries have spiked the demand for coal, pushing nations like Kazakhstan to increase production. This surge in demand, paired with a lack of strong health and safety measures in the workplace, has made respiratory diseases more common among Kazakhstani coal miners.

In the result of Fisher's exact test, four out of seven predictors were found to be statistically significant. These predictors include age, tenure, years of smoking, and trauma exposure.

Years of smoking

No significant association was found between smoking status (current, former, and non-smoker) and respiratory illnesses among the miners. Surprisingly, years of smoking emerged as a statistically significant predictor for certain groups. Specifically, it was found to be a statistically significant predictor for those with only respiratory symptoms, and coal miners who reported both symptoms and diagnoses combined. Additionally, years of smoking was a significant predictor for those who reported no respiratory symptoms or illnesses. This unexpected finding suggests that the duration of smoking may indeed play a role in respiratory health outcomes among coal miners, even in the absence of diagnosed respiratory diseases. This finding is in concordance with a study done by Kuempel et al., in 2009. The study found deleterious effects of coal-mine dust exposure on pulmonary function among both smokers and non-smokers.

Healthy worker effect

From Table 5 we can observe years of smoking in a group that had been smoking for less than 10 years was significantly associated with an increased risk of respiratory disease (RR=4.32, 95%CI: 1.90 - 9.78). However, we do not observe the same trend for other smokers who have been smoking longer than the last period. The observed discrepancy raises concerns about the presence of a healthy worker survivor effect (HWSE).

HWSE refers to the phenomenon where employed individuals, particularly those who remain in the workforce for extended periods, tend to be healthier than the general population due to the inherent selection bias associated with continued employment (Checkoway et al., 2004). This effect can influence research findings by masking or attenuating the true relationship between exposure variables and health outcomes, particularly among longer-tenured workers who have survived in the workforce despite potential health risks.

In the context of our study, the significant association between years of smoking and respiratory disease risk among individuals smoking for less than 10 years may reflect a true biological relationship, where shorter-term smoking exposure has a more pronounced effect on respiratory health. However, the lack of a similar trend among individuals with longer smoking durations suggests the possibility of a HWSE, wherein individuals with poorer respiratory health outcomes may have exited the workforce prematurely due to illness or disability.

Miners' Age and Tenure

The age and tenure of coal miners are key factors in assessing their risk of developing respiratory diseases like coal workers' pneumoconiosis (CWP) in Kazakhstan. Miners are typically aged between 18 to 60 years, aligning with the legal working age, and reflecting the physically demanding nature of the job and its health risks.

Our research shows that miners between 50–66 years old experience a higher incidence of respiratory diseases. This age group often marks the peak of a miner's career, likely including over 15 years of exposure to coal dust, significantly raising their risk for diseases like black lung. This correlation between age, tenure, and dust

exposure suggests that older miners with longer tenures have been exposed to more coal dust, elevating their risk of developing CWP.

This finding is supported by other studies, such as those by Laney A. S. et al. (2009), which demonstrate that both age and long mining careers are linked to higher rates and severity of CWP. Research from the USA and other mining regions confirms that prolonged exposure to coal dust, indicated by long tenures, critically impacts miners' respiratory health.

However, when analyzing data, we encountered a challenge with collinearity, as illustrated in Figure 3, the collinearity test results revealed that age and tenure are so closely linked that it's hard to separate their individual effects on health outcomes. To ensure the accuracy of our findings, we chose to focus on tenure as the primary factor in our final model, since it directly represents the cumulative exposure to coal dust and is a crucial factor in assessing the risk of respiratory diseases. This decision helps maintain the reliability of our results and aligns with our goal to identify critical risk factors for miners.

There is a prevalent age difference among the groups.

The notable age difference observed among the groups, particularly with diagnosed individuals tending to be older, suggests several underlying factors influencing respiratory health outcomes among coal miners. Older miners may exhibit more symptoms due to the natural accumulation of exposure to workplace hazards like coal and silica dust and diesel exhaust. Over time, these exposures can worsen respiratory conditions.

Additionally, older miners typically have longer tenures in the industry, increasing their exposure to these risks. There's also a cultural aspect: older individuals often prioritize their health more and seek medical help sooner, contributing to the higher diagnosis rates in this group.

Younger individuals not seeking diagnosis:

Conversely, younger miners might not seek medical attention as promptly. They may feel resilient or dismiss symptoms, prioritizing work or social life over health, especially if symptoms seem mild. Young miners might not fully realize the long-term implications of untreated respiratory issues, which delays treatment. To address these challenges, targeted health campaigns and screenings could encourage younger miners to take their respiratory symptoms more seriously. Enhancing access to affordable healthcare and offering flexible medical appointments can also help.

Trauma exposure

The link between trauma exposure and respiratory diseases, as seen in Table 5, might suggest a complication in our analysis, known as confounding. Coal mining is a risky occupation, and miners are often exposed to traumatic injuries alongside other job hazards. Those who have worked in the industry for many years are likely to have encountered more dangerous situations, which increases their chances of experiencing trauma.

This prolonged exposure could hinder the true relationship between trauma and respiratory issues because the longer someone works in mining, the more they are exposed to respiratory hazards. Therefore, it's possible that what appears to be an association with trauma might be related more directly to the length of time they have worked in the industry, which increases their risk of developing respiratory diseases.

Limitations and Future Research

Our study of Kazakhstani coal miners employed a cross-sectional design. In occupational settings, cross-sectional studies of diseases with long latencies, such as chronic

respiratory illness, are especially prone to downward selection bias from the HWSE While this design is useful for identifying associations between exposure and health outcomes, it does not allow for the establishment of causality.

The nature of the study implies that the data is provided by the participants, which may result in self-report bias. Additionally, the obtained results could be distorted by recall bias as coal miners were asked to fill out questionnaires referring to past memories. Secondly, the relatively small sample size could limit the generalizability and weaken the statistical power of the study analysis. Despite the mentioned limitations, the present study sheds light on new directions for future research.

To overcome these limitations, future research should aim to include longitudinal designs, utilize objective measures of both exposure and health outcomes, and expand demographic profiling to better understand the complex interactions between occupational exposure and respiratory health. Establishing a control group would also enhance the validity of the findings by providing a baseline for comparing the health impacts of coal dust exposure.

Conclusion

The high incidence of respiratory diseases among coal miners in Kazakhstan underscores a pressing need for enhanced occupational health measures, improved environmental controls, comprehensive training and education, stricter policy and regulation, and continuous longitudinal research. Prioritizing regular and thorough health check-ups using advanced diagnostic tools is essential to detect early signs of lung function impairment caused by dust exposure. Additionally, the work environment in coal mines must be upgraded with better ventilation systems and water

sprays for dust suppression. All miners must be equipped with effective personal protective equipment (PPE), such as respirators.

Education campaigns should also take place to effectively communicate the risks associated with coal dust exposure and emphasize the importance of PPE. Policymakers need to develop robust regulatory frameworks tailored to the mining conditions in Kazakhstan, with regular inspections and penalties for non-compliance to enforce these regulations.

Given the limited long-term data on the health outcomes of coal miners in Kazakhstan, ongoing research and surveillance are crucial, longitudinal studies could provide insights into the progression of respiratory diseases and the effectiveness of implemented health measures.

The findings from this study provide evidence of the high prevalence of respiratory diseases among coal miners in Kazakhstan, driven by age, tenure, and exposure to trauma. Addressing these issues requires a multi-faceted approach that includes better occupational safety practices, enhanced health monitoring, and stricter regulatory oversight. By taking proactive steps, it is possible to significantly improve the respiratory health and overall well-being of coal miners.

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Tables and Figures

Table 1.

Demographic characteristics

	Frequency	Percent
Age		
20–35	35	33.3%
36–50	38	36.19%
50–66	32	30.48%
Ethnicity		
Russian	52	49.52%
Kazakh	24	22.86%
Other	29	27.62%
Smoking status		
Never	46	43.81%
Currently	32	30.48%
Former	27	25.71%
History of previous work in a dusty industry		
No	74	70.48%
Yes	31	29.52%
Tenure (years)		
>0–10	37	35.2%
11–20	27	25.7%
20–30	11	10.4%
30–44	30	28.5%
Smoking years		
Less than 10 years	4	10%
Less than 20 years	13	32.5%
21-30 years	10	25%
More than 30 years 30–44	13	32.5%

Table 2.

Results of Fisher's exact test for diagnosed and respiratory symptoms without diagnosis

	Diagnosed			Symptoms Without Diagnosis		
	n	**%**	**P value**	**n**	**%**	**P value**
	22	21%		13	12.4%	
Age						
20–35	2	9.2%		5	38.6%	
36–50	6	27.2%		4	30.7%	
50–66	14	63.6%	**0.001**	4	30.7%	0.932
Tenure						
>0–10	3	13.6%		4	30.7%	

11–20	3	13.6%		4	30.7%	
20–30	3	13.6%		2	15.4%	
30–44	13	59.1%	**0.002**	3	23.2%	0.838
Smoking						
Current	8	36.3%		7	53.8%	
Former	7	31.8%		2	15.4%	
Never	7	31.8%	0.440	4	30.8%	0.181
Years smoked						
None	11	50%		4	30.8%	
>0–10	1	4.5%		2	15.4%	
10–20	2	9%		3	23.2%	
21–30	3	13.6%		1	7.4%	
>30	5	22.7%	0.397	3	23.2%	**0.028**
Ethnicity						
Russian	11	50%		5	38.6%	
Kazakh	6	27.2%		2	15.4%	
Other	5	22.7%	0.739	6	46%	0.294
Worked in other hazardous industries						
No	17	77.2%		11	84.6%	
Yes	5	22.7%	0.306	2	15.4%	0.195
Trauma						
No	8	36.4%		7	53.9%	
Yes	14	63.6%	**0.000**	6	46.1%	0.182

Table 3.

Results of Fisher's exact test for anti symptomatic and symptoms/diseases combined

	No illness and symptoms			**Diagnosed with symptoms**		
	n	**%**	**P value**	**n**	**%**	**P value**
	70	66.6%		35	33.3%	
Age						
20–35	28	40%		7	20%	
36–50	28	40%		10	28.5%	
50–66	14	20%	**0.004**	18	51.5%	**0.004**
Tenure						
>0–10	30	42.8%		7	20%	
11–20	20	28.5%		7	20%	
20–30	6	8.5%		5	14.3%	
30–44	14	20.2%	**0.016**	16	45.7%	**0.016**
Smoking						
Current	17	24.2%		15	42.8%	
Former	18	25.7%		9	25.7%	
Never	35	50.1%	0.111	11	31.5%	0.111
Years smoked						

None	50	71.4%		15	42.8%	
>0–10	7	10%		3	8.5%	
10–20	6	8.5%		5	14.3%	
21–30	2	2.8%		4	11.4%	
>30	5	7.3%	**0.032**	8	23%	**0.032**
Ethnicity						
Russian	36	51.4%		16	40.5%	
Kazakh	16	22.8%		8	23%	
Other	18	25.8%	0.799	11	31.5%	0.799
Worked in other hazardous industries						
No	46	65.7%		28	80%	
Yes	24	34.3%	0.098	7	20%	0.098
Trauma						
No	57	81.4%		15	42.8%	
Yes	13	18.6%	**0.000**	20	57.2%	**0.000**

Table 4.

Trauma exposure

	Frequency	**Percent**
Traumas at work		
No	72	35.2%
Yes	33	25.7%
Injured body part		
Multiple body parts injured	9	30%
Arms/hands	8	26.67%
Back/Shoulders	5	16.67%
Hips/legs/feet	4	13.33%
Head/neck	4	13.33%
30 (28.57%) out of 100% (105)		
Types of injuries		
Muscle strain	10	34.48%
Fracture	7	24.14%
Cut	5	17.24%
Multiple type of injuries	3	10.34%
Overuse injury	2	6.9%
Amputation	1	3.45%
Burn	1	3.45%
29 (27.61%) out of 105 (100%)		
How injured		
By machinery or tools	8	30.77%
By a fall, trip or slip	8	30.77%
By body stressing	7	26.92%
By body stressing and a fall	2	7.69%

Other: blockage 26 (24.76%) out of 105 (100%)	1	3.85%
Time off work due to injury Less than one week Between 1 and 4 weeks Between 4 and 8 weeks Between 2 and 6 months 26 (24.76%) out of 100% (105)	 9 10 3 1	 34.62% 38.46% 11.54% 3.85%
Trauma effect I was able to continue with ALL my work duties I was TEMPORARILY unable to do my work duties I am PERMANENTLY unable to do SOME of my work duties 30 (28.57%) out of 100% (105)	 12 17 1	 40% 56.67% 3.33%
Reason for trauma Nobody, it just happened My employer A co-worker 32 (30.47%) out of 100% (105)	 28 3 1	 87.50% 9.38% 3.12%

Table 5.

Rate Ratios for Respiratory Symptoms Estimated for Predictor Variables in Poisson regression model among Kazakhstani coal miners

	Coal miners with respiratory diseases and symptoms		
	RR	**P value**	**CI**
Tenure			
11–20	1.47	0.377	0.62 - 3.45
20–30	2.45	0.118	0.79 - 7.55
30–44	2.27	0.081	0.90 - 5.72
Years smoked			
>0–10	4.32	**0.000**	1.90 - 9.78
10–20	1.91	0.189	0.72 - 5.06
21–30	1.13	0.782	0.47 - 2.71
>30	1.64	0.136	0.85 - 3.17
Trauma			
Yes	2.82	**0.000**	1.64 - 4.85

Figure 1.

Prevalence of lung symptoms

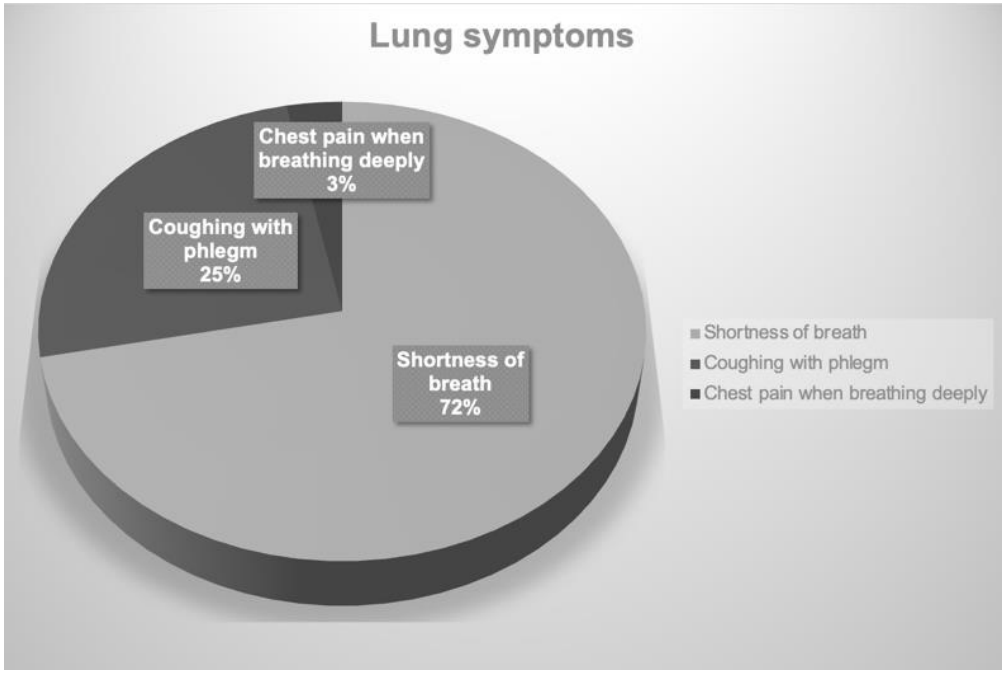


Figure 2.

Prevalence of respiratory illnesses

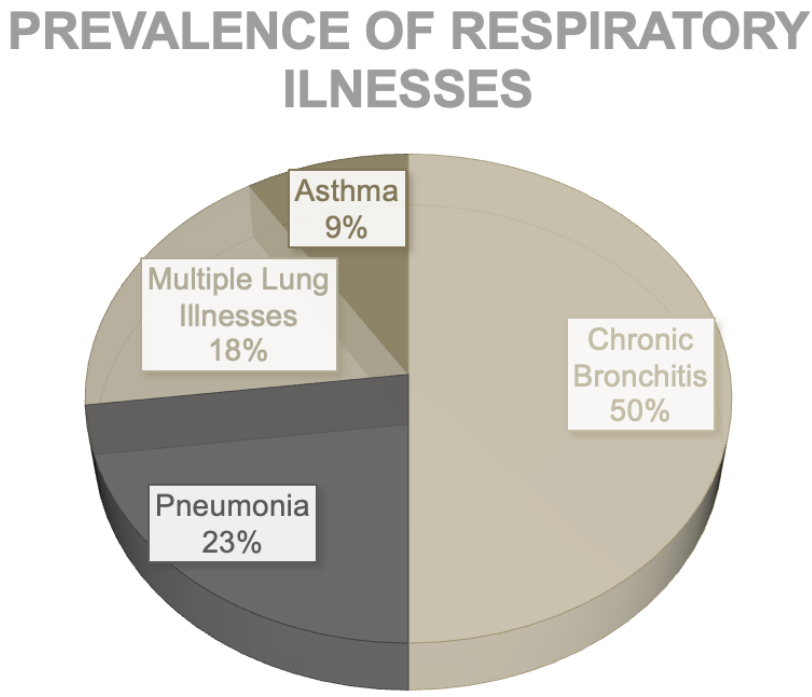
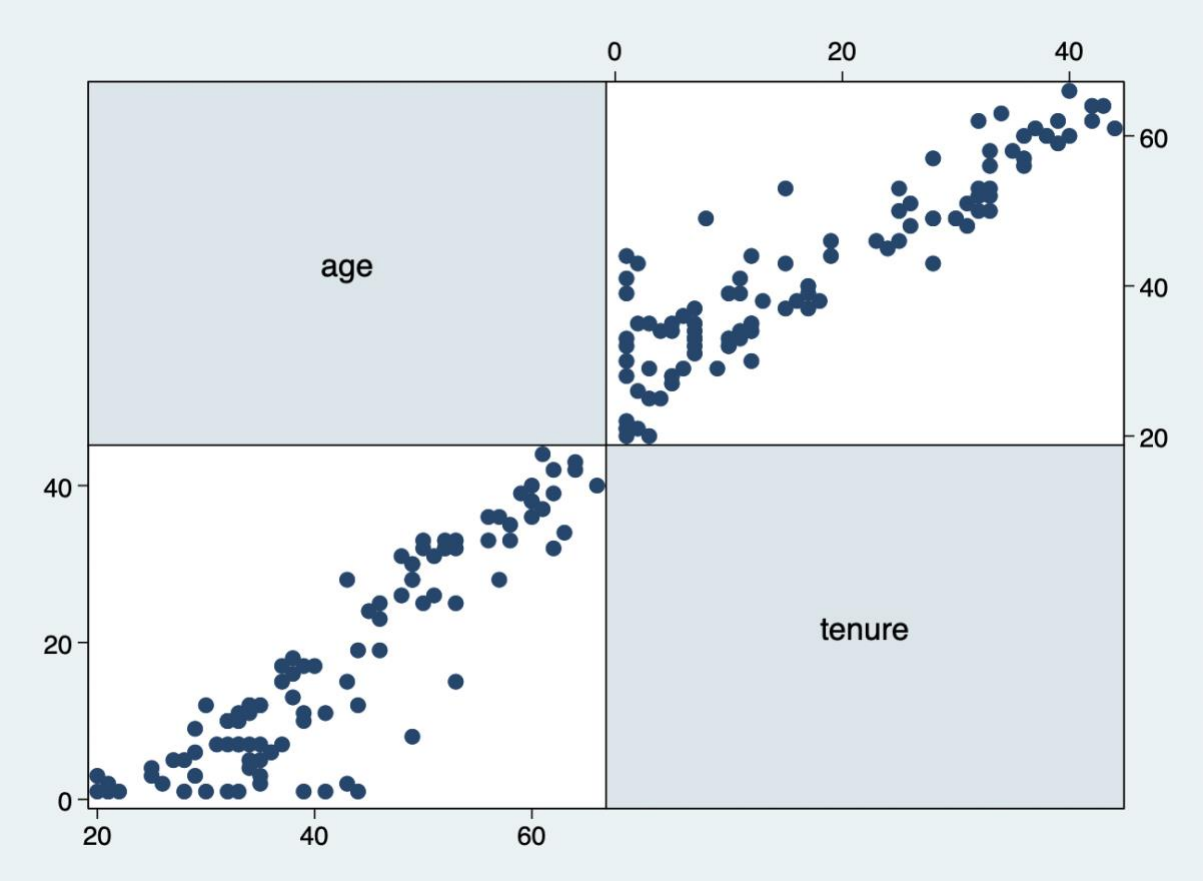


Figure 3.

Graph of collinearity



Appendices

Questionnaire used in the study

Prevalence and Predictors of Respiratory Symptoms Among Kazakhstanis Coal Miners

1. What's your age?
   Enter years: _____

2. What's your nationality?
   Enter nationality: _____

3. What's the name of the mine you currently work at?
   Enter name:____

4. How long have you worked as a coal miner?
   Enter years: _____

5. What are your responsibilities at the mine?
   Enter:_____

6. How long have you worked at the coal face?
- None
- >0-10
- 11-20
- >20

7. Have you worked in other industries involving hazardous amount of dust (Ex.: construction, manufacturing)?
- Yes
- No

8. Do you currently smoke tobacco?
- Current (smoked tobacco in the last month)
- Former
- Never

9. If yes, at what age did you start smoking?
   Enter age:_____

10. How much do you smoke today?
    Enter number of cigarettes:_____

11. How many years have you smoked?

- None
- 20
- 21-30
- >30

12. Have you ever had any of the following pulmonary or lung problems?
- Asbestosis
- Asthma
- Chronic bronchitis
- Emphysema
- Pneumonia
- Tuberculosis
- Silicosis
- Pneumothorax (collapsed lung)
- Lung cancer
- Broken ribs
- Any chest injuries or surgeries
- Any other lung problem that you've been told about by your doctor
- Other: Please specify_____

13. If yes, then at what age did you acquire this problem? How old were you when this occurred?
    Enter age:_____

14. Do you currently have any of the following symptoms of pulmonary or lung illness?
- Shortness of breath
- Shortness of breath when walking fast on level ground or walking up a slight hill or incline
- Shortness of breath when walking with other people at an ordinary pace on level ground
- Have to stop for breath when walking at your own pace on level ground
- Shortness of breath when washing or dressing yourself
- Shortness of breath that interferes with your job
- Coughing that produces phlegm (thick sputum)
- Coughing that wakes you early in the morning
- Coughing that occurs mostly when you are lying down
- Coughing up blood in the last month
- Wheezing
- Wheezing that interferes with your job
- Chest pain when you breathe deeply
- Any other symptoms that you think may be related to lung problems

15. Have you ever had traumas or injuries while at work?
- Yes
- No

16. Which part of your body was the most injured?
    - Head/neck

- Back Shoulders
- Arms/hands
- Hips/legs/feet
- Multiple locations (eg back and shoulder)
- Other: specify_____

17. If yes, then at what age did you acquire this injury? How old were you when this occurred?
    Enter age:_____

18. Was your injury
    - a muscle strain or torn ligaments or muscles?
    - a cut?
    - a burn?
    - a dislocation? (include disc problems in back)
    - a fracture?
    - an internal injury? (eg hernia)
    - an overuse injury (eg RSI, tenosynovitis, carpel tunnel)
    - other: specify_____ .

19. Were you injured
    - by body stressing (eg your back just 'went' from lifting,
    - or bending, or overuse injury)
    - by a fall, trip or slip
    - by machinery or tools
    - other: specify _____

20. How much time off work did you have as a result of your injury/illness?
    - None
    - Less than one week
    - Between 1 and 4 weeks
    - Between 4 and 8 weeks
    - Between 2 MONTHS and 6 MONTHS
    - 6 MONTHS and over

21. What was the effect of your injury/illness on your work?
    - I was able to continue with ALL my work duties
    - I was TEMPORARILY unable to do my work duties
    - I am PERMANENTLY unable to do SOME of my work duties
    - I am PERMANENTLY unable to work
    - Other:specify _____

22. In your opinion, who caused your injury?
    - My employer (eg faulty equipment or unsafe work practices)
    - A co-worker
    - Nobody, it just happened
    - Other: specify_____

23. Overall, I am ____ with my job.
    - Not at all satisfied
    - Not too satisfied
    - Somewhat satisfied
    - Very satisfied

24. Where I work, employees and management work together to ensure the safest possible working conditions
    - Strongly Agree
    - Agree
    - Disagree
    - Strongly Disagree

25. The safety and health conditions where I work are good
    - Strongly Agree
    - Agree
    - Disagree
    - Strongly Disagree

26. What do you like most about your job?
    Your answer:_____
    _____
    _____
    _____
    _____
    _____

27. What do you like least about your job?
    Your answer:_____
    _____
    _____
    _____
    _____
    _____

Participant consent forms

Oral Consent for Semi-structured Interview

"Prevalence and Predictors of Respiratory Symptoms Among Kazakhstanis Coal Miners."

Oral Consent Script

Introduction:

My name is Aida Kassymova. I am conducting a study on the prevalence of respiratory symptoms among coal miners in Kazakhstan from 2020 to the present. This study has been reviewed and cleared by the Nazarbayev University School of Medicine Research Ethics Committee and is conducted as part of the research project at the Master of Public Health Program at Nazarbayev University School of Medicine

Study procedures: I'm inviting you to participate in an interview that will take about 15 minutes. You will be asked open-ended questions regarding demographics, work environment, and your personal feelings, experiences, and needs. For example, "Have you had any recent illnesses or injuries?", "What do you think are the causes of work-related injuries?", or "Do you feel safe in your workplace?

Risks: The study will entail a minimal risk that is not higher than in daily life.
You are not required to answer questions that you do not want to answer or that make you feel uncomfortable. You can also stop participating in the interview at any time. All information you share during the interview will be kept confidential. The study results will be presented only in a generalized form. Below I describe the steps I take to protect your privacy.

Information presented in my report that could identify you will not be published or shared outside the research team unless we have your permission. Any data from this research will be presented or published as the combined data of all participants. This means that the entire group will be reported, not individuals.

Benefits: There are no direct benefits to you, however, your participation in this study may help develop future interventions to improve the health and well-being of miners in Kazakhstan.

Voluntary participation:

- Your participation in this study is completely voluntary.
- You can decide to stop at any time, even halfway through the questionnaire for any reason.
- If you decide to withdraw, there will be no consequences to you.
- If you decide to stop, I will ask you how you would like us to process the data collected up to that point. This may include returning it to you, destroying it, or, using the data collected up to that point.
- If you do not want to answer some of the questions you do not have to, but you can still be in the study.
- If you have any questions about the study, you can contact Principal Investigator Byron Crape, Assistant Professor, Director of the Master of Public Health Program in the Department of Biomedical Sciences, Nazarbayev University School of Medicine, by email:

byron.crape@nu.edu.kz You can also contact Investigator Aida Kassymova at aida.kassymova@nu.edu.kz , as well as by phone +77017474689 via WhatsApp or Telegram.

This study has been reviewed and approved by the Nazarbayev University School of Medicine Research Ethics Committee. If you have concerns or questions about your rights as a participant or about the way the study is conducted, you may contact: the Nazarbayev University School of Medicine Research Ethics Committee. E-mail: nusom-rec@nu.edu.kz

Consent questions:

- Do you have any questions or would like any additional details?
- Do you agree to participate in this study knowing that you can withdraw at any point with no consequences to you?
- May I record an audio and video of this interview without any identifying information?
- The audio and video files for the interviews will be stored on the secure server and immediately deleted from the devices used to record them. All the audio recordings will be deleted immediately after data analysis.