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XRIZOTİL TOZUNUN TƏSİRİNƏ MƏRUZ QALMIŞ İŞÇİLƏR ARASINDA ƏMƏK QABİLİYYƏTİNİN İTİRİLMƏSİ İLƏ MÜŞAYİT EDİLƏN XƏSTƏLƏNMƏ HALLARININ TƏHLİLİ

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Xülasə. Məqalədə 2014-2023-cü illər ərzində “Kostanay Mineralları” Açıq Səhmdar Cəmiyyətinin işçilərinin sağlamlıq vəziyyətinin təhlilinə dair məlumat verilmişdir.

Tədqiqatın məqsədi xrizotil tozlarının təsirinə məruzqalma şəraitində işləyənlər arasında əmək qabiliyyətinin müvəqqəti itirilməsi (ƏQMİ) ilə müşayiət edilən xəstələnmə hallarının səviyyəsini və strukturunu müəyyənləşdirməkdən ibarət olmuşdur. Ümumiyyətlə 21737 “insan-il” göstəricilərinin xəstəlik vərəqələrinin məlumatları əsasında retrospektiv epidemioloji tədqiqat aparılmışdır. Xəstələnmə səviyyəsi E.L. Notkin şkalası üzrə qiymətləndirilmiş, təsviri statistika ANOVA, loqistik reqressiya və zaman trendinin analiz metodlarından istifadə edilmişdir. Diagnostikada XBT-10 təsnifatından istifadə edilmişdir.

Tədqiqat xüsusilə 2020-ci ildən sonrakı dövrdə ƏQMİ ilə xəstələnmə hallarında artmağa meyl olduğunu aşkara çıxarmışdır: hər 100 nəfərə düşən xəstələnmə halları 169,4%, itirilmiş iş günlərinin sayı isə 134,0% artmışdır. Xəstələnmə hallarının ümumi strukturunda tənəffüs sistemi (38,4%), istinad-hərəkət sistemi (23,5%) və ürək-damar sistemi (13,7%) xəstəliklərinin artımı daha yüksək olmuşdur. Kişilər və yaşı 30-dan aşağı olanlar arasında xəstələnmə hallarına daha çox təsadüf edilmişdir. Ən uzunmüddətli ƏQMİ isə iş stajı 40 ildən artıq olan işçilərdə müşahidə edilmişdir. Loqistik reqressiya analizi xəstələnmə ehtimalına yaşın, cinsiyyətin və iş stajının təsir etdiyini göstərmişdir. Beləliklə, xrizotil tərkibli istehsalat tozlarının uzunmüddətli təsirinə məruz qalan işçilərdə xəstələnmə səviyyəsi getdikcə artır. Bu, xüsusən tənəffüs və istinad-hərəkət sistemlərinin xəstəliklərinə aiddir. Tədqiqatdan alınmış nəticələr xüsusilə kişi cinsindən olan az stajlı və yaşlı işçilər arasında profilaktik tədbirlər aparmağın vacib olduğunu sübut edir.

Açar sözlər: əmək qabiliyyətinin müvəqqəti itirilməsi, peşə sağlamlığı, xrizotil asbesti, xəstəliyə meyllik, Qazaxstan

Keywords: temporary disability, occupational health, chrysotile asbestos, morbidity trends, Kazakhstan

Ключевые слова: временная утрата трудоспособности, охрана труда, хризотиловый асбест, тенденции заболеваемости, Казахстан

ANALYSIS OF TEMPORARY DISABILITY MORBIDITY AMONG WORKERS IN CHRYSOTILE PRODUCTION

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The article presents an analysis of the health status of workers at «Kostanay Minerals» JSC over the period from 2014 to 2023.

The aim of the study was to determine the level and structure of morbidity associated with temporary disability (TD) among industrial workers exposed to chrysotile dust.

This retrospective epidemiological study utilized personnel and medical leave records, covering 21,737 worker-years. Morbidity levels were assessed using the E.L. Notkin scale. Statistical methods included descriptive analysis, ANOVA, logistic regression, and time-trend analysis. ICD-10 classification was used to identify leading diagnostic categories.

TD morbidity showed a clear increasing trend over the study period, particularly after 2020. The number of TD cases per 100 workers increased by 169.4%, and the number of lost workdays rose by 134.0%. Respiratory diseases accounted for 38.4% of all cases, followed by musculo-skeletal (23.5%) and circulatory disorders (13.7%). Gender analysis showed higher morbidity among men, while the highest risk by age was observed in workers under 30 and the highest burden by experience in those with over 40 years of service. Logistic regression confirmed significant effects of age, gender, and work experience on the probability of illness.

Workers exposed to chrysotile-containing dust experience a growing burden of illness, particularly from respiratory and musculoskeletal diseases. Findings support the need for stratified preventive programs, with targeted measures for younger, less experienced men and older workers with long tenures.

Introduction. In the past decade, studies on morbidity levels among industrial workers have increasingly focused on the effects of aerosols with predominant fibro genic properties. Especially mineral aerosols with fibrous structures. Among these substances, the most widespread is chrysotile asbestos [1, 2].

Asbestos is a general term for six silicate minerals: one of them – chrysotile, belongs to the serpentine group, while the remaining five – amosite, crocidolite, asbestos anthophyllite, asbestos tremolite, and asbestos actinolite – belong to the amphibole group. Due to its unique physical and chemical properties, asbestos has long been used as a valuable resource in various industrial sectors [3].

Under uncontrolled conditions, exposure to asbestos-containing dust (i.e., free asbestos fibres) increases the risk of developing a number of diseases. The most significant among them are asbestosis, chronic bronchitis, as well as malignant tumours of the upper respiratory tract, bronchopulmonary system, pleura, and other organs and systems [4, 5].

According to data from the World Health Organization (WHO), approximately 125 million people worldwide are exposed to asbestos in the workplace each year, and more than 100,000 deaths annually are attributed to asbestos-related diseases [6].

Based on other studies, the latency period and prognosis of asbestos-related diseases depend not only on the intensity and duration of exposure to hazardous occupational factors, but also on the initial condition of the body and its individual response to harmful exposure [7].

Currently, countries such as Russia, China, Kazakhstan, and India are among the leading producers of chrysotile asbestos. Some countries, that are lacking domestic asbestos deposits, import chrysotile in large quantities and act as major consumer states. Among the Central Asian countries, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan are significant importers of chrysotile [8].

Studying the morbidity rates among workers exposed to mineral fibrous dust is a critical mechanism for assessing occupational health risks and developing preventive measures aimed at protecting workers' health.

Objective of the Study: To determine the level and structure of morbidity associated with temporary disability (TD) among workers of «Kostanay Minerals» JSC.

Materials and methods. To analyze the level of morbidity associated with temporary disability (TD) for the period 2014-2023, the personnel records database of “Kostanay Minerals” was examined. This database included information on employee registration date and issued medical leave certificates with notes on type of illness. Morbidity associated with TD was analyzed based on the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10). Evaluation of TD morbidity from 2014 to 2023 was carried out using the E.L. Notkin scale for assessing indicators of temporary disability. Within this method, temporary disability is quantified using two main indices: the number of temporary disability (TD) cases and the number of lost workdays per 100 employees over a calendar year. The obtained values are then compared with normative thresholds, which makes it possible to classify the overall TD level and

to compare different enterprises or time periods on a unified scale. All statistical analyses were performed using Stata software and included 13,358 cases (the average number of employees over 10 years is 2,086). Two-sample t-test with equal variances was used to evaluate differences in the average number of disease cases between male and female workers. Analysis of Variance (ANOVA) was used to assess the effect of age and length of service on morbidity indicators. To evaluate dynamic trends in morbidity over the study period, the basic growth rate (Tpr) of TD-related morbidity was calculated.

To explore the probability of experiencing at least one case of illness, logistic regression analysis was conducted. The model included categorical variables such as age group, gender, and length of service. Odds ratios and 95% confidence intervals were reported to assess the impact of these factors on morbidity risk.

Results. Trends in Temporary Disability Morbidity (2014-2023)

As shown in Figure 1, the dynamics of TD morbidity among full-time industrial workers at Kostanay Minerals JSC over the period 2014 - 2023 exhibit a pronounced upward trend, particularly from 2020 onward.

Between 2014 and 2019, TD indicators remained relatively stable, with the number of cases per 100 employees ranging from 40.1 to 46.6, and the number of affected individuals

fluctuating between 25.1 and 32.6. However, a sharp increase occurred starting in 2020, most probably linked to the global COVID-19 pandemic, which likely acted as a major contributing factor. By 2023, the number of cases peaked at 116.8 per 100 employees, with total lost workdays reaching 1,255.4 days, more than double the pre-pandemic level in 2019 (515.2 days).

Interestingly, while the average duration of TD per case remained within a relatively narrow range during the study period (11.5 to 13.0 days), a notable decline to 10.0 days was observed in 2023. This may suggest that, despite the increase in incidence, the severity or duration of individual illnesses may have decreased – possibly due to milder, widespread viral infections and streamlined return-to-work procedures implemented during and after the pandemic.

The growth rate of TD cases per worker over the 10-year period was +169.4%, increasing from 0.415 cases in 2014 to 1.119 in 2023 (95% CI: 0.627-0.780), indicating a statistically significant upward trajectory. The average number of lost TD days per worker increased by +134.0%, rising from 5.14 days in 2014 to 12.02 days in 2023 (95% CI: 5.772-8.000),

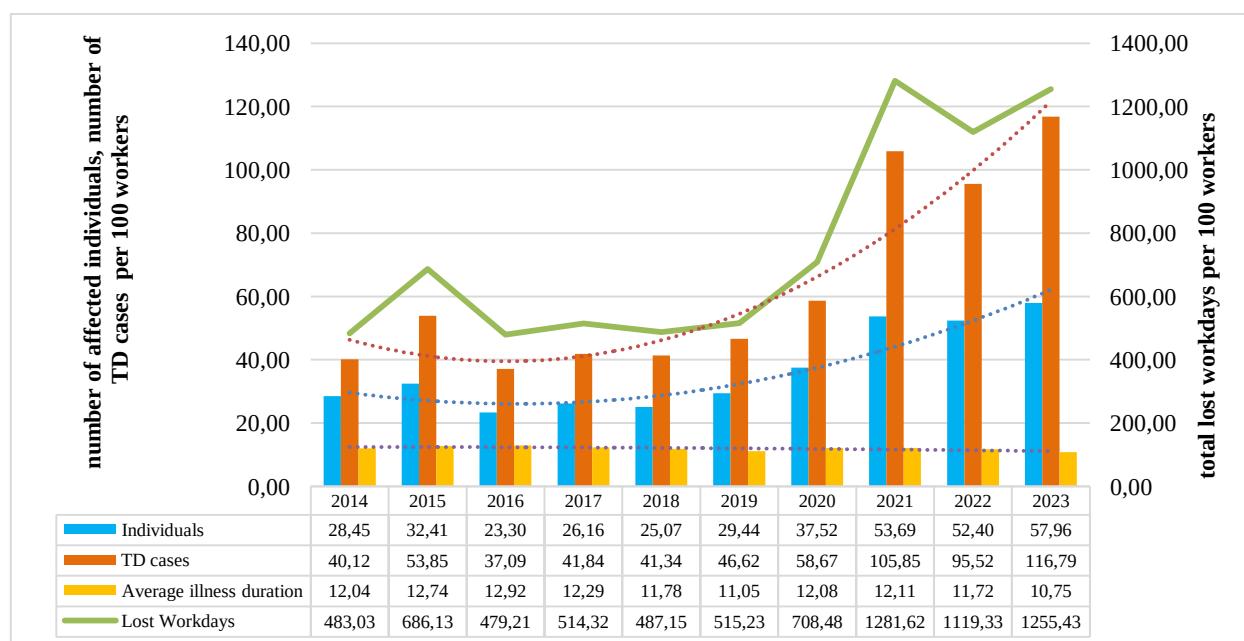


Figure 1. Dynamics of Temporary Disability Morbidity Among Full-Time Workers from 2014 to 2023. Trends in the number of affected individuals, number of TD cases (left axis), and total lost workdays (right axis) per 100 employees

further confirming a heightened disease burden. Conversely, the average duration per TD episode declined by 13.97%, from 11.65 to 10.02 days (95% CI: -2.619 to -0.636), supporting a hypothesis of more frequent but shorter-duration illnesses.

According to the E.L.Notkin scale for evaluating temporary disability, the TD indicators recorded at Kostanay Minerals JSC during the 2014-2023 period correspond to “Above average” for the number of illness cases, and “High” for the number of lost workdays.

Age-Based Analysis of Temporary Disability Morbidity. The analysis of temporary disability (TD) morbidity across age groups (Figure 2) revealed statistically significant age-related differences in both the frequency and burden of illness among workers exposed to chrysotile-containing dust.

Age-based analysis of morbidity showing the number of affected individuals, TD cases, average illness duration, and total lost workdays per 100 employees across different age categories.

Notably, workers under the age of 30 exhibited the highest TD incidence, with 48.22 cases per 100 employees and 77.99 TD episodes. These findings are consistent with

prior literature reporting elevated morbidity rates among younger workers, often attributed to incomplete physiological adaptation, limited occupational experience, and increased susceptibility during early exposure to industrial hazards.

In contrast, the lowest morbidity frequency was observed among workers aged 60 and above, with only 28.32 cases per 100 employees and 57.67 TD episodes. Interestingly, however, this group demonstrated one of the longest average durations of TD (14.74 days), likely reflecting both age-related declines in physiological resilience and the cumulative burden of chronic and occupational diseases, a trend corroborated in asbestos-related morbidity studies. The 50-59 age group showed the highest total number of lost workdays (903.42 per 100 workers).

To quantify these observed differences, a one-way ANOVA was conducted across age groups (N = 21,747), revealing a statistically significant effect of age on morbidity: $F(4, 21742) = 80.52, p < 0.0001$. However, the explained variance ($R^2 = 0.0146$) was modest, indicating that age alone accounts for a proportion of the total variability, underscoring the multifactorial nature of occupational morbidity.

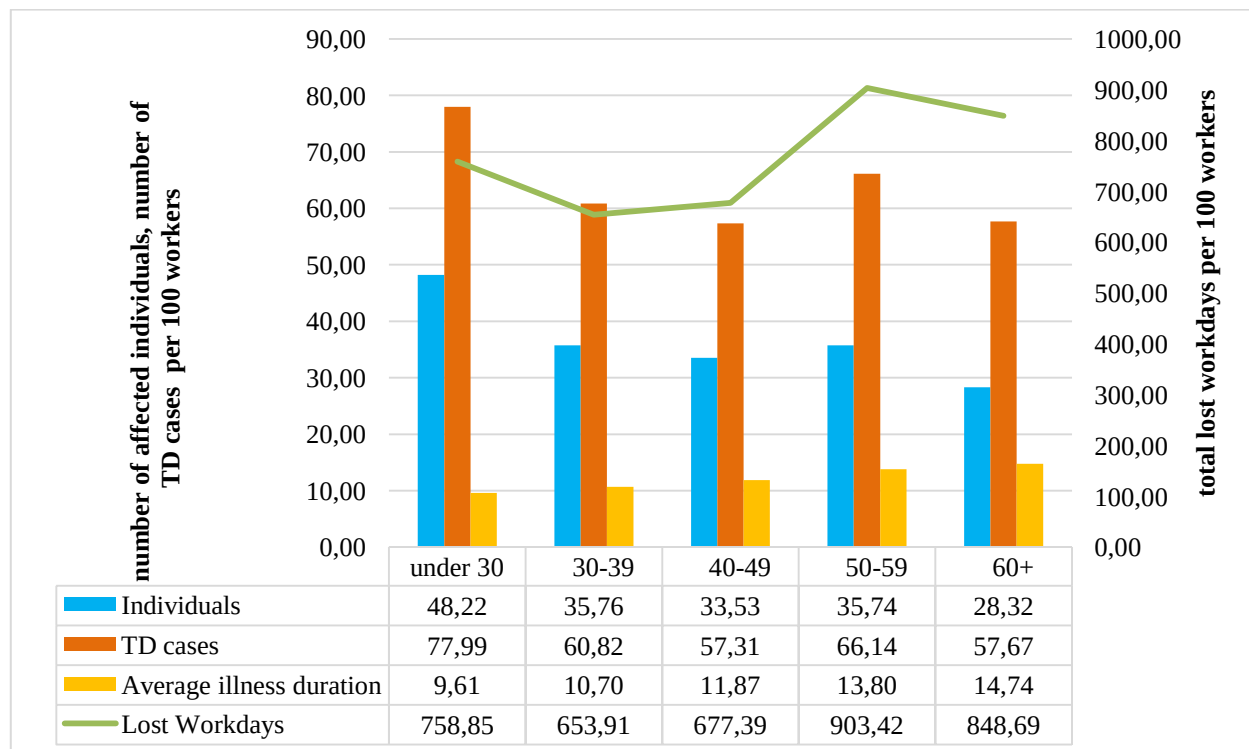


Figure 2. Temporary Disability (TD) Indicators by Age Group

Post-hoc comparisons indicated that workers aged 60+ had significantly lower morbidity than those aged 30-39 and 40-49, while the under-30 cohort exhibited significantly higher rates than all older groups except the 50-59 category. No meaningful difference was found between the 30-39 and 40-49 age bands.

These findings suggest a U-shaped age-morbidity curve, where early-career workers face elevated risk due to biological and occupational vulnerability. While late-career workers experience longer recovery durations despite fewer illness episodes.

Experience-Based Analysis of Temporary Disability Morbidity.

Distribution of TD indicators by years of service, including the number of affected individuals, TD cases, average duration per case, and total lost workdays per 100 employees.

Analysis of TD morbidity across different work experience categories over the 10-year period (2014-2023) revealed a non-linear, U-shaped association between years of service

and health outcomes (Figure 3).

The lowest morbidity was observed in the 20-29 years' experience group, where the number of TD cases was 30.49 per 100 employees, with 51.99 episodes and 677.52 lost workdays. This group also showed a relatively short average TD duration of 13.12 days per case, suggesting a phase of occupational maturity where both adaptive mechanisms and work efficiency may be optimized.

In contrast, the highest burden was found among workers with more than 40 years of experience (50.80 cases per 100 workers, 93.38 TD episodes, 1,452.86 lost workdays) with a mean TD duration of 15.56 days, significantly longer than all other groups.

Interestingly, workers in the 0-9 years' experience category also exhibited elevated morbidity rates (68.21 cases, 742.63 days lost), reflecting potential vulnerabilities among early-career workers, possibly due to insufficient adaptation to occupational hazards, inexperience, or lack of protective behavior - trends that have also been noted in recent occupational health literature.

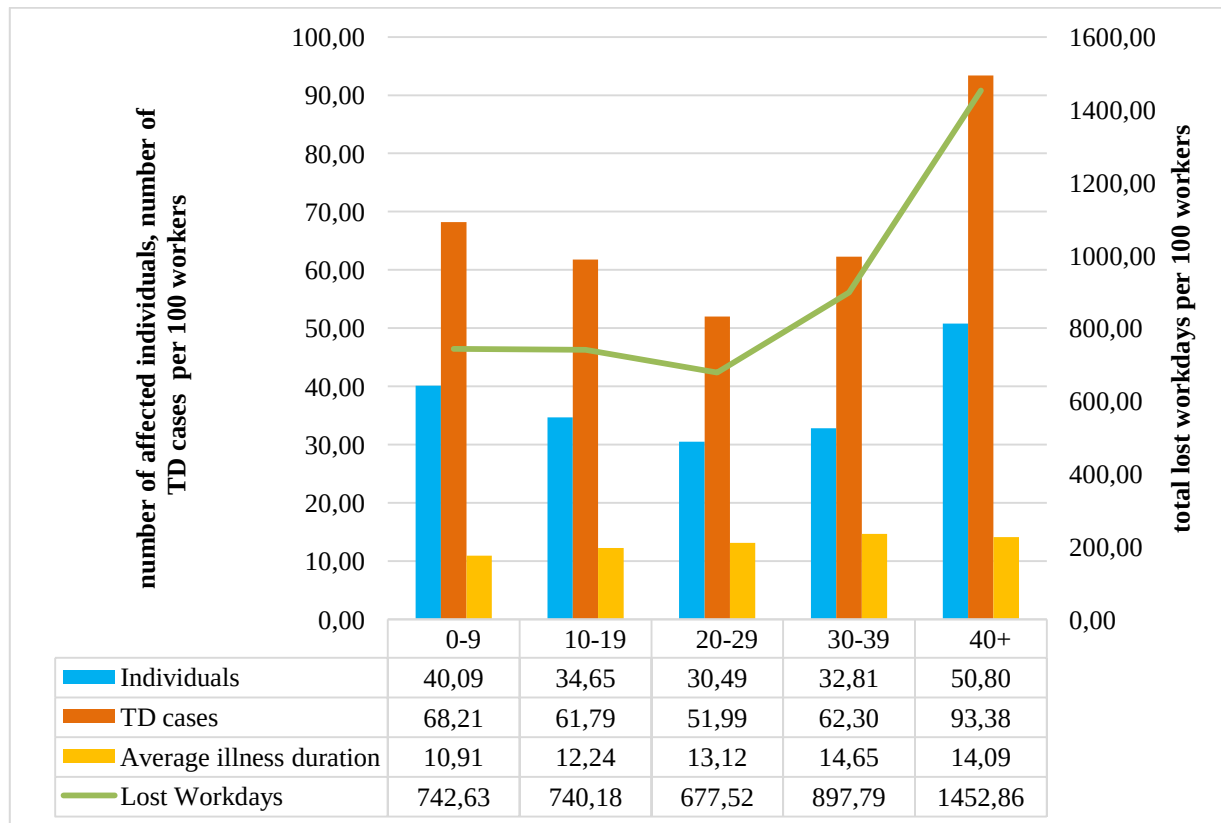


Figure 3. Temporary Disability (TD) Indicators by Length of Work Experience

Statistical comparison using ANOVA confirmed significant differences in TD morbidity across experience groups. $F(4, 21742) = 6.21$, $p < 0.0001$, though the explained variance was minimal ($R^2 = 0.0011$), indicating that while work experience contributes to morbidity risk, other factors such as age, exposure intensity, and underlying health conditions may play more dominant roles.

Further pairwise analysis showed that workers with 30-39 years of experience had a significantly lower average number of TD cases compared to those with 0-9 years (difference = -0.123; 95% CI: -0.178 to -0.066), and a similar trend was observed for the 20-29-year group (difference = -0.074; 95% CI: -0.118 to -0.030).

Although the 40+ years group displayed the highest absolute morbidity indicators, some comparisons to other groups did not reach statistical significance, likely due to variance in group size or confounding factors like age-related retirement filtering healthier individuals.

Predictors of Temporary Disability Risk: Logistic Regression Analysis. Building upon the observed patterns of increasing temporary disability (TD) morbidity across time, age, and work experience, a multivariate logistic regression analysis was conducted to evaluate the influence of key worker characteristics on the likelihood of experiencing at least one episode of illness. The model included categorical variables for age group and length of service, with a total of 21,737 observations analyzed.

Compared to the reference age group (30-

39 years), workers aged under 30 had a significantly lower probability of experiencing illness (coefficient = -0.1409; $p = 0.005$), and the lowest risk was found among those aged 60 and above (coefficient = -1.1977; $p < 0.001$). No significant differences were detected for the 40-49 and 50-59 age groups.

Gender was also a significant predictor: male workers were more likely to have experienced illness compared to females (coefficient = 0.1093; $p = 0.001$). This aligns with earlier t-test findings, which also showed higher average morbidity rates among men.

Work experience demonstrated a nonlinear association with morbidity risk. Using workers with 0-9 years of experience as the baseline, significantly lower risks were observed among those with: 10-19 years (coefficient = -0.0990; $p = 0.006$), 20-29 years (coefficient = -0.2386; $p < 0.001$), and 30-39 years (coefficient = -0.1330; $p = 0.028$).

However, the risk increased again for workers with over 40 years of experience (coefficient = 0.4805; $p = 0.000$), suggesting a potential rebound effect, possibly due to age-related physiological decline, long-term exposure, or cumulative occupational stress.

These results reinforce the previously observed U-shaped relationship between work experience and TD morbidity and highlight the need for tailored preventive and organizational interventions. In particular, young male workers with ≤ 10 years of experience represent a higher-risk group, while those aged under 30 or with 20-29 years of service face the lowest risk.

Table 1. Logistic regression analysis

	Disease risk coefficient	p-value (CI 95%)
Age group		
30-39 y.o.	Reference	
Under 30 y.o.	-0.141	0.005 (-0.238; -0.044)
40-49 y.o.	0.047	0.259 (-0.035; 0.129)
50-59 y.o.	-0.077	0.078 (-0.163; 0.008)
60 + y.o.	-1.198	<0.001 (-1.308; -1.087)
Years of experience		
0-9	Reference	
10-19	-0.099	0.006 (-0.170; -0.028)
20-29	-0.239	<0.001 (-0.331; -0.146)
30-39	-0.133	0.028 (-0.251; -0.015)
40+	0.489	<0.001 (0.219; 0.759)

This analysis supports the design of stratified occupational health programs that consider both demographic and job history variables, ensuring more effective risk management and workforce protection.

Nosological Structure of Temporary Disability Morbidity. An analysis of the nosological structure of temporary disability (TD) morbidity among workers for the period 2014-2023 (see Figure 4) revealed several predominant disease categories based on the International Classification of Diseases, 10th Revision (ICD-10).

The leading cause of TD was Diseases of the Respiratory System (ICD-10 Class X), which accounted for 38.4% of all TD cases. This high proportion is likely associated with seasonal viral infections, poor air quality, and adverse working environments, which are common in industrial settings.

The second most frequent group was Diseases of the Musculoskeletal System and Connective Tissue (Class XIII), representing 23.5% of all cases. These conditions are typically linked to manual labor, prolonged static postures, and repetitive physical strain,

reflecting the physical demands of industrial work.

Third place was occupied by Diseases of the Circulatory System (Class IX), comprising 13.7% of all TD cases. These disorders were more commonly observed among middle-aged and older employees, and are likely associated with long occupational tenure, chronic stress, and age-related health deterioration.

Proportional distribution of illnesses contributing to temporary disability among workers based on ICD-10 classifications. Respiratory, musculoskeletal, and circulatory system diseases represented the most frequent causes between 2014 and 2023.

Discussion. Trends in Temporary Disability Morbidity (2014-2023) showed steady growth over the time. Especially numbers peaked during the COVID-19 period and stayed in the growth trends until 2023. This can be explained by the impact of coronavirus pathogens to the overall health status of employees. If we look at the Nosological Structure of Temporary Disability Morbidity, the top disease, which caused the temporary

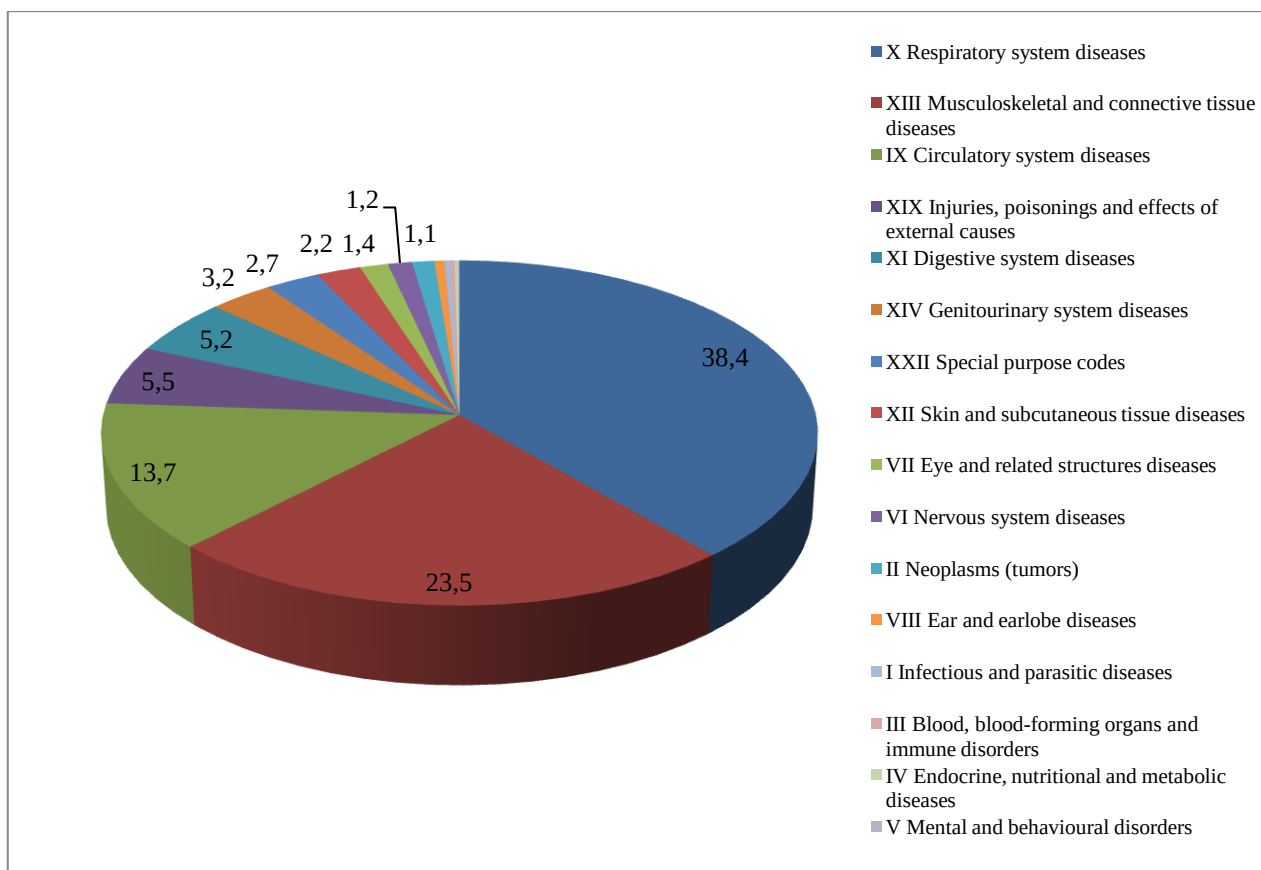


Figure 4. Nosological Structure of Temporary Disability Morbidity per 100 Workers (%)

disability, was the Respiratory system diseases. Obviously, the ongoing pandemic of 2020-2022 years widely affected the already poor state of respiratory organs of workers.

The Age-Based Analysis of Temporary Disability Morbidity showed the unpredictability of the trend. Age categories with the most cases were under 30 and 50-59. The underlying reason for the age category of under 30 to be the top among all age groups could be that the proportion of employees aged 30 and younger far greater than other age groups. Next, the 50-59 age group was the second leading age group because the negative impact of asbestos could be postponed until several years.

For the Experience-Based Analysis of Temporary Disability Morbidity it was revealed that employees with 40+ years of work experience have a significantly higher risk of TD morbidity. This correlates with the previous statement about the postponed effect of chrysotile on the health state of workers.

Finally, the logistic regression analysis showed that all of the above-mentioned variables (age, work experience) have statistically significant impact on the TD morbidity. This means that these two variables greatly define the risk of TD morbidity in employee's work life. For example, i an asbestos factory worker, 59 years old, with 40 years of experience, the chance of negative ending for you is dangerously high.

Conclusion. This 10-year analysis of temporary disability morbidity among workers

exposed to chrysotile-containing dust revealed significant demographic and temporal trends. The overall level of morbidity was rated as "above average" in frequency and "high" in terms of lost workdays, according to the Notkin scale. Respiratory, musculoskeletal, and circulatory diseases accounted for the majority of cases, with notable variation across age and work experience groups.

The study confirmed that younger workers (under 30) and those with less than 10 years of experience were at higher risk of developing illness. Conversely, older workers (60+) and those with over 40 years of service experienced longer durations of disability, reflecting cumulative occupational exposure and physiological decline.

The increase in morbidity after 2013 (and especially after 2019) is explained by the impact of widespread viral respiratory infections, including the COVID- 19 pandemic. These infections disproportionately affected the respiratory system, which is already vulnerable among workers exposed to chrysotile-containing dust.

These findings emphasize the need for targeted occupational health policies, including early intervention for new workers, ergonomic improvements, and chronic disease management for older employees. The sharp post-2020 increase in TD indicators underscores the importance of incorporating pandemic-related health dynamics into workplace risk assessments and health surveillance.

Authors' Contributions

Y.Zh.Otarov, A.K.Kuandykova, Zh.Zh.Zharylqasyn - conceptualisation and methodology.

U.S.Shaikhattarova, A.V.Alekseev, Zh.B.Sabirov - collection and processing of material.

Zh.B.Sabirov, U.S.Shaikhattarova, A.B.Rakhmankulova - statistical processing.

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АНАЛИЗ ЗАБОЛЕВАЕМОСТИ С ВРЕМЕННОЙ УТРАТОЙ ТРУДОСПОСОБНОСТИ СРЕДИ РАБОТНИКОВ, ПОДВЕРГАЮЩИХСЯ ВОЗДЕЙСТВИЮ ПЫЛИ, СОДЕРЖАЩЕЙ ХРИЗОТИЛ

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Резюме. В статье представлены результаты исследования проведенного с целью определить уровень и структуру заболеваемости с временной утратой трудоспособности (ВУТ) среди промышленных работников.

Ретроспективное эпидемиологическое исследование на основе данных кадрового учёта и больничных листов, охватывающее 21 737 «человеко-лет» среди работников АО «Костанайские минералы» за период с 2014 по 2023 годы. Уровень заболеваемости оценивался по шкале Е.Л.Ноткина. Применялись методы описательной статистики, ANOVA, логистической регрессии и анализа временных трендов. Для определения основных диагнозов использовалась классификация МКБ-10.

За исследуемый период отмечена чёткая тенденция роста заболеваемости ВУТ, особенно после 2020 года. Количество случаев ВУТ на 100 работников увеличилось на 169,4%, а количество потерянных рабочих дней — на 134,0%. Наибольший вклад внесли заболевания органов дыхания (38,4%), опорно-двигательного аппарата (23,5%) и сердечно-сосудистой системы (13,7%). Мужчины болели чаще, наиболее высокий риск приходился на работников младше 30 лет, а наибольшая длительность ВУТ — на лиц со стажем более 40 лет. Логистическая регрессия подтвердила значимое влияние возраста, пола и стажа работы на вероятность заболеваемости.

Таким образом, у работников, подвергающихся воздействию пыли, содержащей хризотил, отмечается нарастающая нагрузка по заболеваемости, особенно за счёт респираторных и опорно-двигательных заболеваний. Полученные данные обосновывают необходимость разработки стратифицированных программ профилактики, с прицельными мерами для молодых мужчин с небольшим стажем и пожилых работников с длительным опытом работы.

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