



MANAGEMENT AND HEALTH RISKS OF MINERAL MINING WORKERS (NICKEL)

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ABSTRACT

Nickel mining in Southeast Sulawesi, Indonesia, is a vital economic sector but poses high health risks to workers due to exposure to nickel dust, noise, and heavy working conditions, leading to diseases such as silicosis and high rates of occupational accidents. This study aims to identify the health risks of nickel mine workers, evaluate the occupational safety and health (OHS) system, and formulate a mitigation plan to improve worker welfare and operational sustainability. Using a qualitative approach with quantitative descriptive elements at the Kolaka Regency mine, data were collected through observation, interviews, environmental measurements (dust, noise, vibration, lighting), and secondary analysis on high-risk workers (working period ≥ 6 months) with purposive sampling. Thematic and descriptive analyses were conducted with triangulation for validity. The results showed health risks from physical (noise 88.6 dB, extreme temperatures, vibration), chemical (nickel dust, silica), biological (infection), ergonomic (work posture), and psychosocial (stress) hazards, with clinic visits (3,792 cases) dominated by flu (34%), dyspepsia (12%), and fever (11%). New workers (0–2 years, 43%) and 30–39 years old (40%) are most vulnerable. OHS management includes risk identification (IBPR), health checks, clinics, training, and environmental monitoring, with respirable dust (0.025–0.393 mg/m³) and vibration (< 1.2249 m/s²) below TLV, but low noise and lighting (5 lux) require PPE and additional lighting. Wet preparation ergonomics (score 8, $> TLV$) require administrative control. In conclusion, strengthening HRA, routine environmental monitoring, use of PPE, improving lighting, ergonomics, OHS training, and psychological support for new workers, as well as periodic health data analysis, can reduce health risks, support worker welfare, and safemine operations. Keywords: nickel mining, health risks, OHS, health management, Southeast Sulawesi.

Keywords: health risks; nickel mining; occupational health

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INTRODUCTION

Indonesia is one of the largest nickel producers in the world, with nickel mining concentrated in the Sulawesi region, including Southeast Sulawesi. Companies in this region operate open-pit mines and high-tech smelters, such as Rotary Kiln Electric Furnace (RKEF), which increase processing efficiency but also pose health risks to workers, such as nickel dust exposure, noise, and potential work accidents. This study aims to analyze the health risks of nickel mine workers and formulate mitigation strategies using a quantitative descriptive approach. The relevance of this study is increasing along with the increasing attention to occupational safety and health (OHS) in the Indonesian mining sector (Hasda et al., 2022). Nickel mining is one of the important industries in the Indonesian economy, but this activity also carries significant health risks for workers. According to data from the Directorate General of Mineral and Coal of the Ministry of

Energy and Mineral Resources (ESDM) of Indonesia through Minerba One Data Indonesia (Modi) in 2024 there were 52 accidents resulting in fatalities, 81 serious injuries, 10 minor injuries. In the last ten years, there have been 1642 work accidents involving mining, with 224 workers dying and 883 workers suffering serious injuries (Hadi et al., 2023). These health risks are not only limited to work accidents, but also include exposure to hazardous substances such as silica dust and heavy metals, which can cause chronic diseases such as silicosis and lung cancer (Putro et al., 2024).

One of the main health risks in nickel mining is exposure to silica dust. Silica dust is a crystalline particle that can cause lung diseases such as silicosis, pulmonary fibrosis, and lung cancer. Studies show that long-term exposure to silica can increase the risk of lung cancer by 1.3-1.5 times (Putro et al., 2024). In addition, exposure to heavy metals such as nickel can also cause various health problems, including lung damage and cancer (Hadi et al., 2023). Therefore, managing worker health risks is very important in the nickel mining industry. Managing health risks in nickel mining involves various aspects, from controlling exposure to hazardous substances to implementing an occupational safety and health management system (SMK3). Previous studies have shown that implementing SMK3 can significantly reduce the risk of work accidents and occupational diseases. However, the implementation of SMK3 in the nickel mining industry still faces various challenges, including lack of management commitment, limited resources, and low worker awareness (Hadi et al., 2023).

This study aims to identify and analyze the health risks faced by workers in the nickel mining industry, and to formulate effective management strategies to minimize these impacts. This study aims to map risk factors, such as exposure to nickel dust, hazardous chemicals, noise, and heavy working conditions, which can affect workers' physical and mental health. In addition, this study focuses on evaluating the effectiveness of the occupational safety and health (OHS) management system implemented in the field, including compliance with safety standards, use of personal protective equipment, and training programs. Thus, this study is expected to produce policy recommendations and best practices to improve worker welfare, reduce the number of work accidents, and support the sustainability of safe and healthy nickel mining operations.

METHOD

This study uses a qualitative approach with quantitative descriptive elements to describe the management of occupational safety and health (OHS) and worker health risks in the nickel mining industry. The qualitative approach explores perceptions and working conditions in depth, while quantitative elements support with measurable data from environmental measurements. The study was conducted at a nickel mine in Kolaka Regency, Southeast Sulawesi. The sample was selected using a *purposive sampling technique*, including workers with a minimum work period of six months and high-risk types of work such as a, heavy equipment operators or field workers. This study uses a qualitative approach with quantitative descriptive elements to describe the management of occupational safety and health (OHS) and worker health risks in the nickel mining industry. The qualitative approach explores perceptions and working conditions in depth, while quantitative elements support with measurable data from environmental measurements. The study was conducted at a nickel mine in Kolaka Regency, Southeast Sulawesi. The sample was selected using a *purposive sampling technique*, including workers with a minimum work period of six months and high-risk types of work (eg, heavy equipment operators or field workers).

Data is collected through:

1. Direct Observation: Assess work environment conditions, compliance with the use of personal protective equipment (PPE), and standard operating procedures (SOP) in laboratory, pit, and port areas.
2. In-depth Interviews: Conducted with company doctors, IHOH officers and workers to understand OHS challenges, training effectiveness and psychosocial impacts of work.
3. Environmental Measurements: Measure nickel dust levels, noise, vibration, and lighting using standard tools for quantitative data.
4. Secondary Data: Includes work environment measurement monitoring reports, and clinic visit records for health risk analysis, Mining Health Monthly Report.

Qualitative data from observations and interviews were analyzed thematically to identify patterns related to K3 and health risks. Quantitative data from environmental measurements were analyzed descriptively (percentages, ranges of values). Data triangulation ensured validity by comparing results from all methods.

RESULT

Mining Health Management

Health management in nickel mining companies is a crucial aspect to ensure employee welfare, increase productivity, and comply with occupational safety regulations. This process is carried out in a structured manner through several important stages. First, health risk identification is carried out by mapping potential hazards in the work environment, such as exposure to nickel dust, machine noise, or ergonomic risks due to heavy activities which are stated in the IBPR (Hazard Identification Risk Assessment). Companies usually form an occupational health and safety (OHS) team to conduct routine inspections and risk analysis. Second, regular health checks are mandatory to monitor employees' physical condition, including lung function, hearing, and blood tests to detect the impact of exposure to heavy metals such as nickel. Third, the provision of health facilities at the mine site, such as clinics with trained medical personnel and ambulances, ensures rapid handling in the event of an accident or emergency. Fourth, health training and education are provided to employees to raise awareness of the use of personal protective equipment (PPE), such as masks, safety helmets, and ear protectors, as well as the importance of maintaining a healthy lifestyle. Finally, monitoring of work environment measurements is carried out periodically to assess the effectiveness of health programs, including analysis of health incident data and employee feedback. With this approach, companies can create a safe, healthy work environment that supports operational sustainability. The following is health management data such as Health Risk Profile data, employee visits to the clinic, data on monitoring and measuring the company's work environment, below is data on employee visits to the clinic:

Table 1.
Health Risk Profile

No	Activity	Danger	Risk	Risk Value
1	Wet Dry Laboratory Preparation	Physics (dust), Ergonomics, fatigue	Health Disorders (Respiratory, Concentration,)	20-25
2	Dry Preparation in the Laboratory	Physics (dust), Ergonomics, Fatigue	Health Disorders (Respiratory, Concentration)	20-25
3	Mining Activities	Physics (dust), Ergonomics, Fatigue, lighting	Health Disorders (Breathing, Concentration, Lighting)	20-25
4	Ore Transport Activities	Physics (dust), Ergonomics, Fatigue	Health Disorders (Respiratory, Concentration)	20-25
5	Loading Activity Ora at Jetty	Physics (dust), Ergonomics, Fatigue	Health Disorders (Respiratory, Concentration)	20-25

Table 1 Health Risk Profile, the five activities listed—including wet preparation, dry preparation in the laboratory, development activities, ore heaping activities, and ore loading activities at the jetty—have a uniform risk profile. All activities show physical hazards (dust), ergonomics, and fatigue, with potential health problems in the form of breathing and concentration, as well as lighting in some activities. The risk value for all activities is 20-25, indicating a moderate to high risk level. This indicates the need for mitigation measures, such as the use of personal protective equipment and ergonomic improvements, to reduce the health impacts on workers. Furthermore, the Company provides health services at the clinic that has been provided for employees who experience health complaints, below is the disease data from employee visits to the Company's clinic.

Table 2.
Disease Data Based on Employee Visits to the Clinic

Types of Disease	f	%
Common Cold (Flu)	1274	34
Dyspepsia (Acute Heartburn)	444	12
Fever Unknown (Non-Specific Fever)	407	11
Cough	372	10
Aries of dentine (Cavities)	276	7
Acute Gastroenteritis (Diarrhea)	276	7
Tension Type Headache (Headache)	269	6
Acute Gingivitis (Gum Inflammation)	192	5
Contact Dermatitis (Contact Allergy)	149	4
Myalgia (Muscle Pain)	133	4
Total Employee Visits	3792	100.0

Table 2 health visit data shows that Common Cold (Flu) dominates with 1,274 cases (34%), followed by Dyspepsia (Acute Stomach) with 444 cases (12%), and Fever Unknown (Non-Specific Fever) with 407 cases (11%). Cough recorded 372 cases (10%), while Aries of Dentine (Cavities) and Acute Gastroenteritis (Diarrhea) each accounted for 276 cases (7%). Tension Type Headache contributed 269 cases (6%), Acute Gingivitis (Gum Inflammation) 192 cases (5%), and Dermatitis Contact (Contact Allergy) and Myalgia (Muscle Pain) each accounted for 149 cases (4%) and 133 cases (4%). Total visits reached 3,792 cases, with flu as the most common disease. for the next stage, the company also carries out periodic monitoring of work environment measurements every year. The following is the company's work environment measurement monitoring data below:

Table 3.
Concentration Dust Air Environment Work (Respirable dust Personal)

No	TYPE MONITORING	RESULTS	NAB	KET	Control
1. Location: Saipudin US (crew preparation dry Laboratory)					
1.	Dust Respirable	0.305	3	Normal	Inspection Routine
2. Location: Syamsuddin (supervisor) pit					
2.	Dust Respirable	<0.025	3	Normal	Inspection Routine
3. Location: Augustine (Safety Marine Jetty)					
3.	Dust Respirable	0.393	3	Normal	Inspection Routine

Based on table 3 of the respirable dust measurement monitoring data at three work locations, the measurement results show that all respirable dust values are below the threshold value (NAB), so they are categorized as normal.

Table 4.
Lighting Measurement Data

No	Monitoring	RESULTS	NAB	KET	Control
A. Lighting Local					
1.	Adm. Office Finance	390	300	Normal	Inspection Routine
2.	Adm. Office Mining	415	300	Normal	Inspection Routine
3.	Adm. Office HC	408	300	Normal	Inspection Routine
B. Lighting General					
1.	Area supervisor jetty	157	100	Normal	Inspection Routine
2.	Area preparation dry laboratory	145	300	> NAB	Additions Light
3.	Area supervisor PIT BKM	5	100	> NAB	Additions Tower Lamp

From table 4, the lighting measurement monitoring data in three locations in the local lighting scope, namely the finance office area, mining office, and *human resources office* are categorized as normal and only require routine inspections. Meanwhile, the dry preparation laboratory area, the mine is below standard/below the threshold value, each requires additional lighting such as lamps and *tower lamps*.

Table 5.
Vibration Monitoring Measurement Data

No	Sample	Quantity Exposure Hours Per Day	Results	NAB	Ket	Control
A. Vibration Arm and Hand (HAV)						
1.	Dominggus Operator Excavator Breaker Sany area Jetty	6 – 8 O'clock	0.111	5	Normal	Inspection Routine
B. Vibration all over body (WBV)						
1.	Andi Safaruddin Operator Excavator ex-07.230 Wolo Jetty area	4 – 8 O'clock	0.8954	1.2249	Normal	Inspection Routine

Furthermore, from table 5, monitoring data on arm and hand vibrations and wholebody vibrations for operators is categorized as normal with routine inspection control and regular monitoring of work environment measurements.

Table 6.
Noise Monitoring Measurement Data

No	Monitoring	Results	NAB	KET	Control
A. Noise Area					
1.	Area supervisor Jetty	64.3	85	Normal	Inspection Routine
2.	Area Preparation Dry	88.6		> NAB	Administration, PPE
3.	Area PIT	60.8		Normal	Inspection Routine
B. Noise Personal					
1.	Saipudin US Crew Preparation Laboratory Dry	88.7	85	> NAB	Administration, PPE
2.	Syamsuddin Supervisor mining area	72.4		Normal	Inspection Routine
3.	Augustine Jetty	72.4		Normal	Inspection Routine

From table 6, noise measurement monitoring data for the jetty area and pit area (the mine has a noise level below the NAB, categorized as normal with routine inspection control. However, the noise in the dry preparation area of the laboratory exceeds the threshold value so that it is categorized > NAB with administrative control and the use of appropriate personal protective equipment (PPE).

Table 7.
Ergonomic Monitoring Measurement

No	Sample	Station Work Sit	Station Work Stand	Station Work Dynamic	Manual Handling	Results	NAB	Ket	Control
1.	Hadrian Crew Preparation dry	-	✓	✓	✓	4	4-7	Still Relevant	PPE
2.	Agus Mianto QAQC Division Wet Preparation Crew	✓	-	-	-	8	4-7	> NAB	Administrati on and inspection
3.	Alfryan Hidayatullah Opt. Excavator Operation	✓	-	-	-	4	4-7	Still Relevant	PPE
4.	Rismani Driver Fuel Operation	✓	-	-	-	4	4-7	Still Relevant	PPE

Table 5 ergonomic monitoring measurement data shows that dry laboratory *preparation crew* with an ergonomic score of 4 is categorized as normal and is still relevant to controlling personal protective equipment. While *the wet laboratory preparation crew* has a score of 8, exceeding the threshold value so that administrative control is needed such as reducing working hours to reduce exposure and periodic checks.

Health Risks of Nickel Mining Workers

Nickel mining workers face a variety of complex health risks due to the hazardous working environment. Physical hazards include exposure to high noise from heavy machinery that can cause hearing loss, as well as tool vibrations that can damage nerves and joints. Extreme temperatures, both hot and cold, also threaten workers' physical health. Chemical hazards arise from exposure to nickel dust, silica, and toxic gases such as carbon monoxide, which can cause respiratory problems, skin irritation, and chronic poisoning. Biological hazards are related to the risk of infection due to a humid working environment, such as skin diseases or respiratory infections from bacteria and fungi. Ergonomic hazards occur due to unnatural working postures, lifting heavy loads, and repetitive movements, which can trigger musculoskeletal disorders such as back pain or joint injuries. Psychosocial hazards include work stress due to production pressure, long working hours, and social isolation in remote mining locations, which have the potential to cause mental disorders such as anxiety or depression. Therefore, risk control through training, personal protective equipment, and improving work systems is crucial to protecting the health of nickel mining workers, below are data on several health risks in nickel mining from company data and field observations and interviews with mine workers.

Table 8.
Health Risk Data for Nickel Mining Workers

No	Factor	Risk	Health Impact	Exposure
1	Physics	Voice high/noisy > 85 dBA	Deafness, Noise Induced Hearing Loss (NIHL) - Heat strain (effects that occur in body as a result of heat stress) - Heat syncope (Flow blood does not flow smoothly)	Lab, workshops, Jetty, PIT Crew Environment,

	Climate Work / exposed high temperature	when working statically) -Heat rashes (uncontrolled sweating) lancer) -Heat cramps (No balance salt in the body) Heat exhaustion (Excessive fatigue)	Lab, All Office, Laboratory, Jetty
	Temperature low	Frosbite (damage skin and the underlying network as a result exposure temperature Which very cold)	Security Post, All Office, Laboratory
	Radiation Non Ionizing	Infrared (cataracts), ultraviolet (conjunctivitis).	Crew Environment, workshop
	Radiation Ionizing	Radioactive/alpha/beta/gamma/X (damage to human body cells)	Laboratory
	High air pressure, Decompression / Diver	Coison Disease (blockage of blood vessels) blood in spinal cord and brain)	Environment, Jetty
	Vibration Arm > NAB (hand arm vibration)	Reynaud's Disease, Polyneuritis (blood flow to certain parts of the body is reduced due to constriction vessels arterial blood)	Lab, workshops, PIT (Heavy Equipment),
	Body Vibration > NAB (whole body Vibration)	Disturbance metabolic processes, Increased heart rate, Muscle fatigue, Problem Sleep, dizziness, back pain, low back pain (LBP)	Lab, workshops, PIT (Heavy Equipment)
	Lighting General > NAB	Potential decline quality of vision, glare, eyes get tired easily.	Post Security, All Office, Laboratory, Jetty, PIT
	Lighting Local > NAB	Potential decline quality of vision, glare, eyes get tired easily.	Post Security, All Office, Laboratory, Jetty, PIT
2	Chemistry	irritation, allergy, corrosive, asphyxia, systemic poisoning, cancer, damage / fetal abnormalities, pneumoconiosis, effects of anesthesia (narcosis), Influence genetics.	Fuel Storage, Laboratory, LB3
	Inhalation		LB3, Clinic, Workshop, SCM
	Ingestion		LB3, Clinic, Workshop, SCM
	Skin Contact		MHR Hauling, PIT, Laboratory
	Dust (PNOS)	Disturbance breathing, lung damage	
3	Biology	Rabies, Hepatitis	Canteen, Security post, Clinic, Enviro, Drilling, Nursery
	Virus		
	Bacterial	Anthrax, Leptospirosis, Brucellosis, TB, Tetanus	
	Fungal	Dermatophytoses, Histoplasmosis	
	Parasite	Ancylostomiasis, Schistosomiasis	
4	Ergonomics	Physical fatigue, muscle pain, deformity bone, deformation, dislocation, LBP.	Logistics, Laboratory, Office, A2B Operator
5	Psychosocial	Stress, psychosomatic, somatic.	Security Post, Laboratory, Clinic, PIT.
	Work organization (leadership type, work relationships, Communication, security, Type of work (monotonous, repetitive, overworked, underworked, Work shift, remote)		

Data shows various occupational health risk factors consisting of five main categories. Physics: Noise >85 dBA in the lab, workshop, jetty, and PIT is at risk of causing deafness (NIHL). Exposure to high temperatures in various work areas can trigger heat strain to heat exhaustion, while low temperatures in security posts and laboratories have the potential to cause frostbite. Non-ionizing and ionizing radiation in the workshop and laboratory can cause cataracts to cell damage. Vibration of the arms and body in the lab, workshop, and PIT (heavy equipment) is at risk of causing metabolic disorders to back pain. General and local lighting >NAB in various locations can reduce the quality of vision. Chemistry: Inhalation, ingestion, and skin contact with chemicals in fuel storage, LB3, and workshops have the potential to cause irritation to cancer. Dust (PNOS) in MHR hauling, PIT, and laboratories can damage the lungs. Biology: Viruses, bacteria, fungi, and parasites in the canteen, clinic, and drilling area are at risk of causing diseases such as rabies, tuberculosis, and dermatophytoses. Ergonomics: Unergonomic working positions in logistics, laboratories, and heavy equipment operators can cause physical fatigue to back pain. Psychosocial: Work organization, such as monotonous or shift work in security posts, laboratories, and PITs, has the potential to trigger stress and psychosomatic disorders.

Table 8.
Working Period of nickel mining workers

Years of service	f	%
0 – 2 Years	1567	43
25 years	990	27
> 5 Years	1081	30

Table 8 Health visit data based on length of service shows that the group with a length of service of 0–2 years had the highest number of visits of 1,567 cases (43%), followed by the group >5 years with 1,081 cases (30%), and the group 2–5 years with 990 cases (27%). Total visits reached 3,638 cases, with the new group (0–2 years) visiting health services the most frequently.

Table 9.
Age of Nickel Mining Workers

Age	f	%
15 - 19 Years	36	1
20 - 29 Years	1240	34
30 - 39 Years	1438	40
40 – 49 Years	523	14
50 – 59 Years	283	8
> 60 Years	118	3

Health visit data based on age shows that the 30–39 age group has the highest number of visits with 1,438 cases (40%), followed by 20–29 years with 1,240 cases (34%). The 40–49 age group contributed 523 cases (14%), 50–59 years 283 cases (8%), >60 years 118 cases (3%), and 15–19 years only 36 cases (1%). Total visits reached 3,638 cases, with the 30–39 age group being the most dominant

DISCUSSION

Mining Health Management

Health management in nickel mining shows a systematic approach to reduce worker health risks. Based on the Health Risk Profile, all main activities such as wet/dry preparation, mining, transportation, and ore loading have moderate to high risks (value 20-25) due to physical hazards (dust), ergonomics, and fatigue, which have the potential to cause respiratory, concentration, and lighting disorders. Clinic visit data recorded 3,792 cases, with flu (34%),

dyspepsia (12%), and non-specific fever (11%) as the main complaints, indicating that environmental exposure and psychosocial factors such as work stress contribute to worker health. To address this, the company implemented mitigation such as the use of personal protective equipment (PPE), regular health checks, and the provision of clinic facilities with trained medical personnel for rapid treatment. Health risk assessments for laboratory personnel and nickel mine workers need to be identified, evaluated, and controlled to ensure workers are free from work-related diseases (Komlasari, D, et al., 2023; Keprdijen ESDM No. 185, 2019)

Work environment monitoring showed mixed results. Respirable dust measurements at three locations (laboratory, pit, and jetty) were below the threshold limit (TLV), requiring only routine inspections. However, lighting measurements indicated deficiencies in the laboratory dry preparation area (145 lux, <300 lux) and pit areas (5 lux, <100 lux), requiring additional lighting and tower lamps. Noise in the laboratory dry preparation area (88.6 dB) and for individual dry preparation crew (88.7 dB) exceeded the TLV (85 dB), requiring administrative controls and PPE such as ear protection. Arm/hand and whole-body vibrations in heavy equipment operators were within normal limits, requiring only routine inspections. This monitoring underscores the importance of technical and administrative interventions to maintain a safe work environment. Research over the last five years has shown that hot working climate, worker knowledge, and fluid intake are significantly related to the incidence of dehydration in nickel mining workers, especially in the workshop area, so that control of the work environment, education, and routine health monitoring are very important to reduce the impact of these health risks (Salsabila, A et al., 2023; Keprdijen ESDM No. 185, 2019).

Ergonomic aspects are also an important concern. Ergonomic measurement data shows that dry preparation employees, excavator operators, and drivers have an ergonomic score of 4, which is still relevant and only requires PPE. However, wet preparation employees have a score of 8, exceeding the NAB (4-7), so they need administrative control such as reducing working hours and regular check-ups to prevent musculoskeletal disorders. Health training and education provided by the company increase worker awareness of the importance of PPE and a healthy lifestyle. With regular monitoring, incident data analysis, and employee feedback, companies can continue to improve health programs to create a work environment that supports worker welfare and operational sustainability. The use of personal protective equipment (PPE) is the final stage of hazard control, although the use of PPE will be maximized if carried out with other controls such as elimination, substitution, engineering and administrative (Yuliani, I, et al, 2019: Keprdijen ESDM No. 185, 2019).

Health Risks of Mine Workers

Nickel mining workers face significant health risks from a variety of factors. Physical hazards such as noise >85 dBA in the laboratory, workshop, jetty, and pit can cause deafness (Noise Induced Hearing Loss), while exposure to high temperatures triggers heat strain to *heat exhaustion*, and low temperatures risk causing *frostbite*. Arm and body vibrations from heavy equipment in the pit and workshop increase the risk of metabolic disorders, back pain, and muscle fatigue. Substandard lighting in various work areas has the potential to reduce vision quality. Chemical hazards from inhalation, ingestion, and skin contact with chemicals in fuel storage, LB3, and workshops can cause irritation, poisoning, and cancer, with dust (PNOS) in the pit and laboratory at risk of lung damage. Biological hazards such as viruses, bacteria, and fungi in the canteen, clinic, and drilling area increase the risk of diseases such as tuberculosis, rabies, and dermatophytoses, indicating the need for strict environmental control. Physical hazards such as: hot working climate, noise, lighting and worker knowledge, and fluid intake are significantly related to the incidence of dehydration in nickel mining workers, especially in workshop areas, pit areas, laboratory areas, so that control of the work environment, education, and routine health monitoring are very important to reduce the impact of these health risks (Salsabila, A et al., 2023; Keprdijen ESDM No. 185, 2019).

Ergonomic and psychosocial hazards also affect workers' health. Unergonomic working positions, repetitive movements, and heavy lifting in logistics, laboratories, and heavy equipment operations cause physical fatigue, muscle pain, and musculoskeletal disorders such as low back pain. Psychosocial factors such as monotonous work, long shifts, and isolation in security posts, laboratories, and pits trigger stress, psychosomatic disorders, and mental health problems. Clinic visit data showed a total of 3,638 cases, with workers aged 30–39 years (40%) and 0–2 years of service (43%) most frequently experiencing health complaints, possibly due to adaptation to harsh working environments or intense initial exposure. The 20–29 age group (34%) and >5 years of service (30%) also showed significant visit rates, reflecting the cumulative impact of prolonged risk exposure. The aging process remains a major risk factor for various chronic diseases such as cardiovascular disease, diabetes, cancer, and neurodegenerative disorders, due to the decline in organ function and accumulation of cellular damage that occurs with age (Salsabila, A et al., 2022)

Risk control is crucial to protect workers. The use of personal protective equipment (PPE) such as masks, ear protection, and heat-resistant clothing must be applied consistently to reduce exposure to dust, noise, and extreme temperatures. Occupational safety training and health education can increase worker awareness of environmental hazards and how to prevent them. Improvements in workplace design, such as adequate lighting, ergonomic tools, and good ventilation, are needed to minimize physical, chemical, and biological risks. To address psychosocial issues, companies need to implement stress management, effective communication, and psychological support, especially for new workers and those in remote locations. Regular health monitoring and routine inspections of the work environment will help detect health problems early and ensure the effectiveness of mitigation measures, thereby supporting worker welfare and operational sustainability. New workers generally do not have a deep understanding of the ins and outs of the job. On the other hand, as a worker's length of service increases, so does the worker's knowledge and skills and the safety aspects of the work they do (Rahayu, et al. 2021).

CONCLUSION

This study revealed that nickel mining workers in Kolaka Regency, Southeast Sulawesi, face significant health risks from physical (noise, extreme temperatures, vibration), chemical (nickel dust, silica), biological (viral, bacterial infections), ergonomic (unnatural working postures), and psychosocial (work stress) hazards. Clinic visit data showed flu (34%), dyspepsia (12%), and muscle pain (4%) as the main complaints, with new workers (0–2 years, 43%) and 30–39 years old (40%) most vulnerable. These health risks are exacerbated by harsh working environments, such as high noise in the laboratory (88.6 dB, >NAB) and low lighting in the mine (5 lux, <NAB). Health management in nickel mining companies is carried out systematically through risk identification (IBPR), periodic health checks, provision of clinics, K3 training, and monitoring of the work environment. Environmental measurements show that respirable dust (0.025–0.393 mg/m³) and vibration (maximum 0.8954 m/s²) are below TLV, but noise and lighting in some areas require interventions such as PPE and additional lighting. Ergonomic aspects, especially for wet preparation workers (score 8, > TLV), require administrative control to prevent musculoskeletal disorders, highlighting the importance of improving work design. To reduce health risks, companies need to strengthen the implementation of HRA (Health Risk Assessment), implement monitoring of work environment measurements and their evaluation periodically every year, use of PPE (masks, ear protectors), improve lighting, and improve workplace ergonomics. Safety training and health education should be prioritized for new workers, while psychological support is needed to overcome work stress in remote locations. Regular monitoring and analysis of health data will ensure the effectiveness of mitigation, support worker welfare, and the sustainability of safe and healthy nickel mining operations.

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