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Exploring the Public Health Impacts of Mining Activities on Workers and Societies: A Systematic Review

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ABSTRACT This systematic study investigates the health and well-being effects of mining communities in high- and low-income countries and possible contributory variables. A thorough search was conducted across two databases (PubMed and Google Scholar). Articles that examined workers and communities in mining villages and had results about health or well-being at the individual or community level were chosen. There were thirteen articles in total included. In the mining villages, there was evidence of a low self-reported health status and an elevated prevalence of infectious and chronic diseases. Relationship breakdown, inadequate family well-being, a lack of social connections, and limited access to healthcare services were all mentioned in the studies. To enhance the coexistence of mining activities, this study concludes by highlighting the broader health and well-being effects connected with mining activity, which should be monitored and addressed in addition to the environmental health impacts.

INTRODUCTION

The mining sector has been crucial in shaping the economies and societies of the nations and regions where minerals have fueled economic growth (Carney and Gushulak 2016). In addition, a substantial amount of quantitative research demonstrates the connections between mining activities and public health impacts (Mactaggart et al. 2016; Leuenberger et al. 2021). Studies have reported on sexually transmitted diseases (STIs), HIV/AIDS, industrial epidemics, malaria, and other diseases among mine workers and people who lived in mining areas (Coelho et al. 2011; Stuckler et al. 2013; Baltazar et al. 2015).

The direct effects of the environment on health are well-researched at the community level. For instance, research conducted on Goan communities in India found that the health effects of emissions of fugitive dust and the ensuing bad air quality caused by mining operations were detrimental (Noronha 2001). According to research done in a gold-mining area in Malaysia, headaches, lightheadedness, and skin and eye irritation increased with cyanide exposure. In a similar finding, research carried out in a gold-mining community in Kenya discovered that the environment had dangerously high concentrations of chemicals that might be harmful to human health (Ngure et al. 2014; Hassan et al. 2015). These included an increased risk of respiratory illnesses, heart and other key organ failure, infertility in women, and cancer due to poor air quality caused by iron ore operations (Rodriguez-Fernandez et al. 2016; Noronha 2001).

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More recently, it has been acknowledged that a wide range of factors can have an impact on communities, such as migrant populations, unstable economies, or land degradation brought on by an increase in mining activity (Fadlallah et al. 2020; Odo et al. 2020; Leuenberger et al. 2021). There is evidence of a rise in mental health problems, a decline in social connections, and a reduction in treatment accessibility in communities affected by mining activities in high-income countries (HICs) (Mactaggart et al. 2016; Miller et al. 2019, 2020). The determining variables are part of the social determinants of health paradigm, which explains the wider effects on health that result from modifications to an individual's living environment, social context, economics, and community (WHO 2015; Mactaggart et al. 2016).

Although there has been some indication of a connection between mining and wider effects on community health and well-being approximately forty years ago, there has not been any recent cumulative data exploring public health impact. Regarding the mid- to longer-term effects of mining operations on health and well-being, there is significant uncertainty. It is critical to comprehend these effects on mining communities as they experience social, economic, and environmental instability associated with the "boom and bust" phases of the mine life cycle (Mactaggart et al. 2016). The government, health systems, community-based organisations, and mining firms can all benefit from the findings, which will help improve the planning and monitoring efforts and provide guidance for future mine projects. This comprehensive research aims to review the health and well-being effects of mining communities in high- and low-income countries, as well as possible contributory variables.

What is previously known about this topic

1. It is known that exposure to chemicals and poisons in the environment directly from mining operations can pose health concerns to humans.
2. There is growing evidence that mining operations have a positive and negative impact on the social, physical, and economic environments in which communities reside and that these elements in turn have an impact on outcomes related to health and well-being.
3. There is no comprehensive review of the effects of mining on public health that takes into account wider, more indirect, and frequently longer-term health and well-being results.

What this study adds

1. Despite studies being conducted in various locations and nations, there is evidence of similar results for individual and community well-being linked to the mining sector.
2. It is crucial to include not only physical health but also the mental health, and well-being of individuals and communities to paint a more complete picture of how mining may impact local communities.
3. A systematic study publication will bolster the body of evidence to guide the creation of policies and programs that more effectively address the health and well-being issues of mining communities.

METHODOLOGY

Searching Strategy

The researchers thoroughly searched the electronic databases of PubMed, and Google Scholar in November 2023 to find original research, including works published between 2013 and 2023. PRISMA compliance was maintained throughout this search. The researchers combined MeSH terms and free-text words, using keywords like mining, low- and middle-income countries, health or individual well-being, quality of life, and resource industry to find relevant publications. To find any more pertinent papers, the researchers also looked through the reference lists of previous evaluations. Table 1 presents comprehensive information about the search strategy. The Rayyan-Intelligent Systematic Review program (https://www.rayyan.ai) was the only tool used to gather all included abstracts for additional screening after two investigators (RA and SP) independently searched the articles.

Eligibility Criteria**

Studies are eligible for inclusion if they meet the following criteria:

Table 1: Searching strategy used in database

PubMed	"Developing Countries"[MAJR]) AND "Female"[MeSH]) AND "Humans"[MeSH]) AND "Male"[MeSH]) AND "Mining"[MAJR]) AND "Personal Satisfaction"[MAJR]) AND "Public Health"[MeSH]) AND "Social Determinants of Health"[MAJR]Filter: Publication date 2015-2023
Google Scholar	Low-middle income countries (OR region* OR remote OR isolated*) AND mining (OR mine OR 'extractives industry' OR 'resource industry') AND health OR individual well-being (OR happiness OR 'quality of life' OR 'personal satisfaction') OR community well-being (OR 'social capital'). Filters: Publication date 2015 - 2023

1. the articles should be original
2. written in English
3. published between 2015 and 2023
4. reported health outcomes of mining communities in low-middle income countries.
5. The researchers excluded the articles if the full text was unavailable.

Study Selection

RA, AW, RAY, and YT assessed the titles and abstracts separately after the first literature search. Mutual consensus was used to settle any disputes that arose during this screening procedure. To remove duplicate articles and perform a thorough analysis of the entire papers, the researchers used Mendeley Desktop Ver. 2.107.0 for Mac. Predetermined inclusion criteria were fulfilled by the included studies, and those that did not satisfy the requirements were explicitly explained when they were omitted. Until a consensus was reached, any conflicts arising from the selection of studies were thoroughly examined.

Data Extraction

Each study's data extraction was carried out by three investigators (RA, ABB, DAM and RAY) after they had each individually evaluated the full-text papers. The source articles were consulted to settle any contradictions or inconsistencies in the data. The data extraction process was standardised and carried out using Microsoft Excel.

RESULTS

Search Results

A total of 30 abstracts were evaluated following title screening, language screening, duplicate removal, and availability of the articles (Fig. 1). The abstract screening was done by two authors, and any differences were discussed, and if needed, settled by consulting with other authors. Following the examination of the complete articles, it was decided to eliminate those published before 2000 because of non-scientifically based study designs. Additionally, articles reporting baseline studies or program evaluations in mine communities that omitted any discussion of the relationship between mining activity and outcomes related to health or well-being would also be excluded. The narrative synthesis of fourteen articles. The health outcomes and socioeconomic determinants of the health approach were represented in recurring themes found in the synthesis.

Study Characteristics

To retrieve information pertinent to the review issue, a methodical approach was employed in Table 2. Studies were carried out in communities that mined gold in sub-Saharan Africa (3), gold in Papua Indonesia (2), gold in Sudan (1), taconite in Minnesota, USA (1), silver and gold in Bolivia (1), coal in China (2) and 2 uncategorised mines. The majority of the research (n = 12) employed quantitative methodologies, all of which were cross-sectional study and prospective studies, and were carried out between 2015 and 2021.

Health Impacts and Related Health Outcomes

There were 791 participants (385 men and 406 women) from nine study sites in Burkina Faso, Mozambique, and Tanzania who took part in 83 participatory focus group discussions. It was reported that the dust created during stone grinding finds its way into the surrounding communities. People cough and become ill more often as a consequence (Leuenberger et al. 2021). Another study also reported reparatory diseases or lung diseases

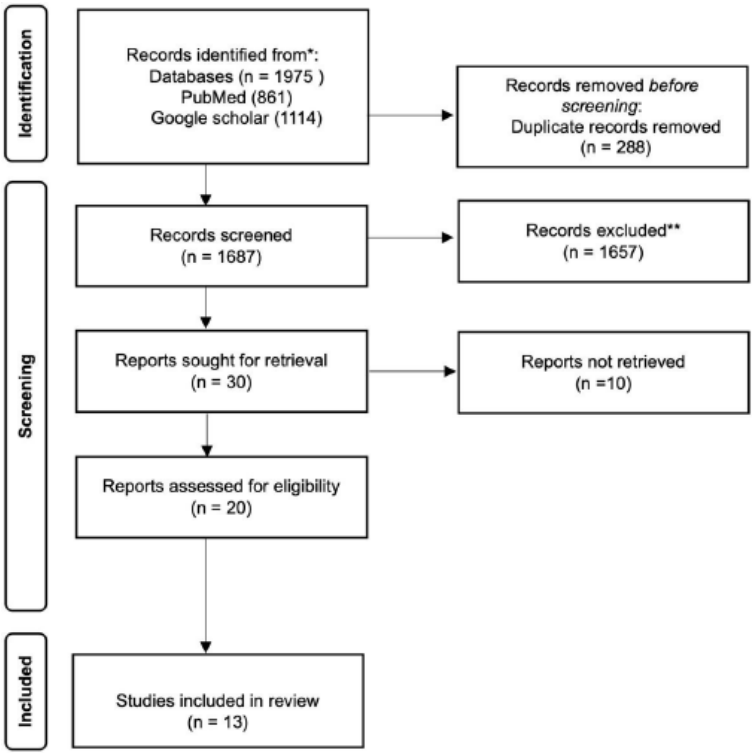

Fig. 1. Prisma Flow Chart of study selection

such as restrictive ventilatory defect (RVD) or parenchymal were common among miners and communities in Minnesota, USA (Odo et al. 2020).

Miners also reported having non-communicable diseases (NCDs) such as type 2 diabetes obesity (especially abdominal obesity) and hypertension (Rodriguez-Fernandez et al. 2016; Fan et al. 2017; Mawaw et al. 2017, 2019). In addition, the most common co-occurring conditions were malaria and tuberculosis, then chronic obstructive pulmonary disease, asthma, stroke, and cancer were also noted among miners in Papua, Indonesia (Rodriguez-Fernandez et al. 2016). Furthermore, after controlling for age and gender, higher blood pressure, elevated blood cholesterol, overweight/obesity, and elevated blood glucose were all predicted by a longer work history (> 10 years) (Rodriguez-Fernandez et al. 2015, 2016). In addition, another study also reported blood pressure (BP) was the highest in coal miners, followed by abnormal ECG (electrocardiograph), pulmonary function, and radiograph (Wu et al. 2019).

Moreover, a study among 1.2 million households in sub-Saharan Africa also found stunting and underweight prevalence increased more strongly upon mine opening (Dietler et al. 2021). Miners and communities living around the mine area are also vulnerable to accidents and injuries such as traffic accidents causing them to become physically disabled (Leuenberger et al. 2021). Disabilities are also reported among certain women who give birth to babies with open-cleft conditions and rheumatism, which is created because of the dust, and sight problem in workers (Leuenberger et al. 2021). The use of unsafe water is what causes miscarriage (Leuenberger et al. 2021).

In addition, apart from physical illness, mining workers and people who live around mines are at risk of mental illness and psychological distress (Salas et al. 2015). In two studies Australian work-

Table 2: Articles included in the synthesis with an extracted summary of study type, target population, mining type, and data collection method

First author and year	*Population and location*	*Mining type*	*Primary outcomes*
Leuenberger et al. 2021	In nine research locations in Tanzania, Burkina Faso, and Mozambique (sub-Saharan Africa). This multi-country qualitative study involved 791 individuals (385 men and 406 women) in 83 participative focus group conversations.	Gold mines	Diseases: Coughs and increased HIV transmission are common among miners and residents around gold mines. Traffic accidents have resulted in cripples as well as accidents. Disabilities include rheumatism brought on by dust exposure, open-cleft births in certain women, and visual issues in laborer. Long-distance travel for medical care is associated with mortality. Maternal fatalities in our town occurred because of a number of factors, including deliveries that occurred while the mother or infant was travelling to the hospital or because a woman could not afford to attend to the health center. Fortunately, things have changed since then. Since the mine opened, people's lives have been shorter, and their health has completely disappeared.You may all perish inside when a home collapses due to vibrations caused by fissures. The cause of miscarriages is the usage of contaminated water. Well-being: Living forever in the dust is difficult, and societies no longer enjoy high standards of living. We don't think our water is reliable.
Dietler et al. 2021	For longitudinal studies, a total sample 1.2 million houses with data within fifty-two mine-panels' vicinity were chosen, resulting in 41,896 families and 32,112 children. A multi-country examination of sub-Saharan Africa's Demographic and Health Surveys (DHS).	Gold mines	After the mines were opened, the number of underweight and stunting declined more sharply in the areas surrounding the mining sites. While cases of diarrhea and wasting were no discernible differences.
Rodriguez-Fernandez et al. 2015	Using 5-year medical surveillance data, metabolic markers of Non-Communicable Disease risk were evaluated among personnel with a total 6496 miners of a large copper-gold mining in Papua, Indonesia. People between the ages of 18 and 68 who had been working for at least a year between 2008 and 2013 made up the study cohort. Using WHO guidelines, repeated measurements of blood pressure, blood sugar, cholesterol, and body weight were used to assess risk factors.	Copper	The rates of metabolic risk indicators were notably elevated and showed a significant rise from the baseline to the 5-year follow-up. More years of employment (> 10 years), after controlling for gender and age were associated with higher odds of elevated blood pressure elevated cholesterol (AOR=1.16), elevated cholesterol (AOR=1.13), overweight/obesity (AOR=1.14), and persistently elevated blood pressure (AOR=1.26) at baseline; at the 3-year follow-up, the odds of persistently elevated blood glucose (AOR=1.62) and incident (AOR=1.33) were also predicted.
Miller et al. 2018	A cross-sectional study, sample were adults and working in the Australian resources industry at the time, 150 potential volunteers considered for this research.	Resources sector	The study's findings also showed that Australian resource workers were more likely to seek mental health specialists' help in the preceding year when they had limited social support and a stronger sense of hopelessness. The focus should shift to developing initiatives that encourage social support for workers in Australia's resource sector.

Table 2: Contd...

First author and year	*Population and location*	*Mining type*	*Primary outcomes*
Miller et al. 2020	To determine the incidence of bullying among Australian FIFO, its causes, and its correlation with psychological distress, a cross-sectional survey study methodology was employed. In the Australian resources industry, 580 FIFO workers submitted responses. The Beck Depression Inventory II, the Beck Hopelessness Scale, and the Negative Acts Questionnaire-Revised were the main outcome measures. To investigate the relationship between bullying, the risk of suicide, and clinical depression, logistic regression models were developed.	FIFO workers in the Australian resources sector	Approximately one-third (32.3%) of the respondents reported moderate to severe depression, and over half (55.7%) reported experiencing bullying at work. Bullying was substantially correlated with being older, and having a supervisor who didn't encourage teamwork. Bullying was linked to an almost threefold rise in the probability that participants would report a higher risk of suicide. Participants who experienced bullying were also almost 2.5 times more likely to report having clinical depression. Bullying among FIFO workers in Australia has become a concerning problem. There was a substantial correlation found between bullying and increased risk of suicide and severe depression.
Rodriguez-Fernandez et al. 2016	A total 22.550 patient records from two clinic sites in Papua, Indonesia. Diagnosed cases of ischemic heart disease, stroke, hypertension, diabetes (types one and two), asthma, cancer, HIV-AIDS, malaria and tuberculosis, were extracted. Data were gathered as entries from records covering January–December 2013 for the International Classification of Diseases, 10th Revision. The interconnection between the illness loads was shown as overlapping prevalence estimates reflecting comorbidities using a unique application of the Circos program.	Gold mines	In total, NCDs accounted for 38% of all illness cases, with type-two diabetes and hypertension accounting for most of these instances. With 5310 cases reported, malaria accounted for the greatest single share of the illness burden, followed by type 2 diabetes. The most common co-occurring conditions were malaria and tuberculosis, then chronic obstructive pulmonary disease, asthma, and stroke. Comorbidities between asthma and TB and between hypertension and tuberculosis, cancer and tuberculosis, and both were noted.
Mawaw et al. 2017	Cross-sectional research was carried out on a sample of 2.749 workers' and contractors' 2010 from occupational health examination files in the Democratic Republic of the Congo (sub-Saharan Africa). Anthropometric, medical, occupational, sociodemographic, and behavioral data were gathered and evaluated. ODH disease status was determined using WHO standards. The model utilized was a multivariate logistic regression one.	Uncategorized	High prevalence for obesity, diabetes, hypertension, and pre-ODH. Age, professional level, kind of employment, gender, and reported alcohol usage all raised the prevalence of ODH. While lowering obesity, smoking ten or much more cigarettes per day raised the risk of diabetes and hypertension.
Mawaw et al. 2019	Using occupational health data that were acquired from all	Uncategorized	The prevalence of obesity rose from 4.5% to 11.1% between 2010 and 2015, diabetes from

Table 2: Contd...

First author and year	*Population and location*	*Mining type*	*Primary outcomes*
	contractors and workers in Congo (sub-Saharan Africa) who had pre-employment or follow-up medical examinations over the time frame of January 2010 to December 2015. This research was conducted using a longitudinal, retrospective cohort design with three time intervals. Repeated paired t tests examined changes in the mean values of quantitative risk factors, while a chi-square test assessed changes in prevalence and categorical risk variables over time. A linear projection model was used to anticipate the subsequent morbidity of ODH over the next 10 years, up to 2025.		11.9% to 15.6%, and hypertension from 18.2% to 26.5%. Obesity, diabetes, and hypertension are expected to reach 25%, 24%, and 42% of the population by 2025, respectively, if no preventative measures are taken.
Odo et al. 2018	The Taconite Workers' Health Study (TWHS) in Minnesota. In accordance with ILO norms, miners were tested using a medical history questionnaire, spirometry tests, and chest x-rays. Both past and present occupational exposure evaluations were acquired; the former measured about 679 individual samples for respirable dusts, including silica, in 28 key work activities during the research. The calculation of cumulative silica exposure, expressed as (mg/m3) × years, included multiplying the annual concentration of silica job exposure by the total number of years worked. The basis for the abnormalities on the chest x-ray came from a B-reader's arbitration agreement with a third B-reader. To diagnose spirometric restrictive ventilatory defect (RVD), forced vital capacity (FVC) less than lower limits of normal for age, height, race, and gender was measured. Multivariate Poisson regression was used to determine prevalence ratios (PR) of exposure-outcome relationships, along with 95% confidence intervals (CI).	Taconite mine	The prevalence of parenchymal abnormalities on chest x-rays (PR = 1.30, 95% CI = 1.00–1.69) and RVD prevalence (PR = 1.41, 95% CI = 1.09–1.81) were found to be correlated with cumulative silica exposure, assuming an unchanged historical exposure trend and primarily based on current study measurements. On the other hand, no correlations were found between silica exposure and either parenchymal (PR = 0.87, 95% CI = 0.45–1.70) or RVD (PR = 0.76, 95% CI = 0.41–1.40) outcomes when exposures were defined using known actual historical values.This study showed that the method employed to quantify cumulative exposure had a significant impact on the predicted connection between lung disease and silica dust exposure. RVD limitation on spirometry was associated with cumulative values based on cautious estimates of historical exposure, estimated from recently observed respirable silica. Using this method, silica exposure was also strongly linked to an increase in parenchymal findings on chest x-rays. On the other hand, when real historical data was utilized to predict cumulative silica exposure, similar findings were not present. These variations draw attention to the difficulties in measuring occupational dust exposure, the possible influence on the predicted exposure risk, and the necessity of collecting high-quality, long-term exposure data in sectors of the economy where inhaled respirable dusts pose a concern.

Table 2: Contd...

First author and year	*Population and location*	*Mining type*	*Primary outcomes*
Salas et al. 2015	The research population included 200 official silver miners employed in distant Peru, 137 informal gold miners in Chile, and 153 miners in Bolivia (South America) who worked in a cooperative. The European Working Condition Survey's Spanish short form was used to evaluate high work demands, little work control, little social support at work, and exposure to bullying and violence at work. The threshold for psychological discomfort was set at a score of >4 on the general health questionnaire. By adjusting for possible confounding and effect modification by country, logistic regression models were used to evaluate associations between psychosocial work environment and psychological distress.	Silver and gold	High number of Bolivian, Peruvian, Chilean miners reported having psychological discomfort. In the twelve months before to the poll, 55% of the miners reported experiencing violence. Both social support and workplace expectations were high (median 5.5 on a range from 3-6 to 12.5 on a scale from 7 to 14).Miners in high strain (OR, 7.2; 95% CI, 1.7-29.9) and active (odds ratio [OR], 6.8; 95% confidence interval [CI] 2.1-22.7) jobs were more likely to experience distress than those in low strain jobs, even after controlling for country and other pertinent exposure variables. Increased chances of distress were also correlated with workplace violence (OR, 1.86; 95% CI, 1.1-3.1).
Wu et al. 2019	For this research, 12.597 participants and 11.061 persons in total were recruited in 2015 and 2016 as part of the Chinese Occupational Health Risk Assessment Program and Occupational Disease Monitoring. An electrocardiograph, spirometer, sphygmomanometer, and radiograph machine were used to measure the chest radiographs, PF, BP, and ECG of coal workers, respectively.	Coal mines	Among coal workers, abnormal PF, radiograph, ECG, and blood pressure (BP) were the most prevalent conditions. Abnormal BP, ECG, PF, and radiograph readings in coal miners were highly linked with age, years of dust exposure, smoking, drinking, kinds of labor, and mine size. Eighty persons, or 0.34% of coal miners, were diagnosed with coal workers' pneumoconiosis (CWP) in 2015–2016.
Fan et al. 2017	Data on 4341 coal workers in China were collected, including biochemical, anthropometric, and demographic information. The blood lipid levels were used to diagnose dyslipidaemia. The relevant risk variables for dyslipidemia were evaluated using univariate and multivariate logistic regression analysis.	Coal mines	According to the study, 40.46% of people had high LDL-C, 25.84% had low HDL-C, 35.08% had high TG, and 38.08% had high TC. Overall, 68.28% of individuals (95% CI: 66.90–69.66%) had dyslipidemia. Dyslipidemia was associated with a number of characteristics, including age, sex, marital status, monthly family income, kind of occupation, length of service, smoking status, smoking index, drinking status, quantity of alcohol drank daily, high fasting glucose, hypertension, obesity, and abdominal obesity. Our study's conclusions demonstrated the significant prevalence of dyslipidemia among Chinese coal miners as well as the existence of many risk factors for the illness.

Table 2: Contd...

First author and year	*Population and location*	*Mining type*	*Primary outcomes*
Fadlallah et al. 2020	In the Abideya area of Sudan (Northern Africa), 211 miners answered questionnaires on their health and sociodemographic details. Composite score variables were created for the evaluation of underlying risk factors for the susceptibility of the miners (migrants and non-migrants) based on data and existing research. Six additional composite variables were developed, one of which looked at immigrant status.	Traditional gold mine	There is a correlation between variations in health behavior characteristics and the immigration status of traditional gold miners. The provision of water, sanitation, and hygiene facilities is positively correlated with the health behaviors of both internal migrant miners and their local counterparts. Knowledge and perception are also important factors that influence the health behavior of local miners, and secondary education is an additional modifier for the immigrants' health behavior.

ers experienced workplace bullying and were diagnosed with severe depression. Participants who experienced bullying were almost three times more likely to report having a higher risk of suicide. Additionally, bullying was linked to participants' almost 2.5 times higher likelihood of reporting clinical depression among miners (Miller et al. 2019, 2020).

Health Impacts Related to Health Determinants

Environmental Determinants (Water, Air Quality, Housing and Living Environment, Soil and Land, Sanitation)

Several determinants of health are listed in the review, in separate categories and subcategories, and this reports on numerous impacts that were closely related to one another within a particular category (such as water and air within the environmental determinants) or between categories (such as resettlement linked to the environmental, social, and economic determinants). Water and air pollution were under the heading of environmental consequences. For instance, participants in sub-Saharan Africa reported that blasting simultaneously caused pollution in the air and rainwater. More precisely, they claimed that the dust from blasting is carried by air to their homes, where it is subsequently cleaned into their water collection systems by rain that falls off their roofs (Fadlallah et al. 2020; Leuenberger et al. 2021).

Regarding the broader determinants of health, various changes brought about by the mining intersected. According to the participants, there were various changes associated with resettlement, that is, they had to purchase household goods (economic impact), lost their land for agriculture (environmental impact), received compensation (economic impact), or did not feel at home in their new location (social impact). These changes ultimately had an impact on the participants' health and well-being. Another illustration is the unstable household income, as a result of a reduction in agricultural land and limitations on artisanal mining and fishing (which have an environmental impact), community members are hoping to find work in the mine (which has an economic impact), and there has been a rise in theft and sexual activity (which has a social impact) (Fadlallah et al. 2020; Leuenberger et al. 2021).

Economic Determinants (Generating Activities, Working Conditions and Job Opportunities, Unemployment, Living Costs, Poverty, Compensation, Economic Benefits)

The dynamic result centred on economic issues, and the various themes that surfaced were all connected to the miners' income levels. The miners and people living in the mine area were primarily concerned with the impact on their customary sources of income, which included farming and artisanal mining. People in several communities believed that the mine had appropriated their land

for artisanal mining or agriculture, even though these areas had been reallocated. As a result, they were obliged to cease these activities, or in the case of the latter, carry them out illegally. Similar problems with fishing were also documented in two research sites in Mozambique, where locals' access to the ocean was restricted once the mine started operating (Leuenberger et al. 2021).

However, the mines offered fresh employment possibilities. Study participants in sub-Saharan Africa mentioned jobs requiring unskilled labour, like security guards and construction workers. During the talks, opportunities within the mine (such as gardeners) were also highlighted. However, a study from Tanzania indicated that these chances were extremely restricted, linked to difficult working conditions, and had negative health consequences, such as back pain and blindness, after working in the mine. Announced job prospects in Burkina Faso proved to be hollow promises. The participants expressed frustration regarding unjust employment conditions, unfavourable working conditions, and social insecurity while they sought employment and a regular income to support their family's necessities (Leuenberger et al. 2021).

Some studies mentioned that unemployment was a particular challenge. As a result, they disclosed their occasionally lethal attempts to take additional materials from the mine or gather stones (that is, ore or gemstones) from the tailings for their gain. Sexual exchanges were another means of making money, but they were also associated with serious health risks, such as HIV. While Tanzania and Mozambique have reported on this, Burkina Faso participants have not reported on this subject. Personal conversations with study participants, however, revealed Burkina Faso to be experiencing the same pattern. It is highly possible that, as married housewives, they did not feel comfortable talking about it, even though it might disproportionately affect women (Dietler et al. 2021; Leuenberger et al. 2021).

Economic factors were also connected to the payment of land compensation during community resettlement in Mozambique and Tanzania. Nonetheless, the majority of participants felt that this compensation was insufficient to change for what they had lost, and they were not satisfied with it either. It was stated in both countries that the men used the money they received carelessly for their entertainment. Growing living expenses were seen as a problem, particularly for necessities like food and clean water. These effects, which included low health and well-being symptoms like stress, exhaustion, or weakness, were especially connected to the majority of participants' difficult financial circumstances. The inability to pay for medical care, particularly diagnosing and treating infections that cause fever or diarrheal, also worried the miners and people who are living in mining areas (Rodriguez-Fernandez et al. 2016; Miller et al. 2019, 2020).

Two studies indicated economic gains for their communities in Sub Saharan Africa. For instance, at one research site in Tanzania, a portion of the local security guards' mine-related pay went towards funding community development initiatives. Participants were therefore relieved that they were exempt from having to donate to the community fund. In a similar vein, participants in Mozambique confirmed receiving in-kind support or interventions from the mine, which enabled them to use their funds for necessities like food and medical treatment (Dietler et al. 2021; Leuenberger et al. 2021).

All things considered, the general subject of possessing, producing, or pursuing revenue is a very dynamic one for the communities surrounding industrial mines, especially in light of the shifting local means of subsistence. Even though the mine offered brief windows of opportunity, being able to pay for necessities for their health and well-being was a big worry that was not always guaranteed.

Social Services and Organisations (Health Care, Culture and Community Dynamics, Schooling)

The three main areas that affected social services and social organisations were health care, community dynamics (including cultural components), and education. Except for one research location in Mozambique, community residents positively rated health sector interventions funded by the mine. The building of new healthcare facilities, the renovation of current facilities' materials, equipment, and infrastructure, the deployment of mobile clinics or ambulance services, HIV testing and counselling, and the treatment of other diseases were among the various interventions that the participants discussed. For example, in Tanzania, the participants also stated that the mines provided support for treating impacted children with open clefts.

Even with these well-received healthcare improvements, several participants expressed dissatisfaction with lengthy wait times and inadequate services in medical facilities. They added that the rising rate of illness and the disappearance of traditional medicinal plants meant they would need to visit the doctor more frequently (Leuenberger et al. 2021).

Both good and negative problems with internal community dynamics surfaced throughout the review. Some studies connected the introduction of the mine to an increase in migration, which in turn was linked to HIV-related death and increased HIV spread (Rodriguez-Fernandez et al. 2016; Miller et al. 2020; Leuenberger et al. 2021).

DISCUSSION

This systematic review generally found the impacts of mining projects on the broader determinants of health and public health outcomes. The primary reason for the increased burden of mental illness and the spread of diseases was the mining operations' effects on social dynamics and the environment. In addition to crimes and accidents, elevated death rates were linked to chemical exposure, STIs, and HIV. The introduction of industrial mining resulted in a decline in the participants' subjective well-being, especially in terms of housing instability and changes in sources of income. The construction or financial support of water access points, roads, schools, and health facilities among other social services.

Conditions Related to Culture and Environment

Studies reported the effects of land and soil (including agriculture), air, water, housing and living conditions, sanitation, and hygiene on environmental determinants of health. The primary concerns were the availability of trustworthy water sources and the quality of the water. Residents of the area complained about wells that had entirely dried up because of the increased water demand brought on by the mining operations, as well as how the chemicals used in the mine had contaminated various bodies of water. People who live close to coal and gold mines also believe that the rainwater is contaminated with chemicals or particulates from the mine that wash into their water collection system from the roof. Water was reported to be flowing from gold mines in Tanzania to nearby settlements, either naturally occurring or as a result of a tailing dam burst (Fadlallah et al. 2020; Dietler et al. 2021; Leuenberger et al. 2021).

Participants from every nation reported a variety of water-borne illnesses and skin rashes following exposure, all of which were linked to water scarcity and contamination. They discovered a rise in miscarriages and birth defects, which they connected to contaminants in the water. However, participants in nearly every research site reported feeling relieved as a result of the upgrades made to the water infrastructure. The mining corporations erected a large number of new water pumps or taps. The participants stated that their health and well-being were correlated with the availability of water (Mensah et al. 2015; Leuenberger et al. 2021).

The most significant thing that studies mentioned was how the mine's dust was contaminating the surrounding area. Notably, reports of high dust emissions were especially common in the vicinity of coal and gold mines, where blasting (explosions) associated with mining were frequent. It has been reported that the dust from gold mining contains compounds or 'particles' that may have harmful effects, such as altering the water's colour (Fashola et al. 2016; Lansdown 2018). Studies described substantial amounts of black coal mine dust piled on surfaces both inside and outside of the homes. Heavy mining truck traffic on nearby roads was another source of dust, especially at locations with unpaved major access roads (Carney and Gushulak 2016; Leuenberger et al. 2021). A study in Tanzania acknowledged that mining companies periodically treated the main access roads, for example, by watering the road, to lessen the amount of dust they generated. It is reported dust was a significant problem that prevented hygienic conditions from being maintained. Dust can cause respiratory illnesses, and to a lesser extent, eye infections. Respondents reported an increasing number of disease cases, even if several of the ailments cited were acknowledged as not being particularly new. Moreover, there has reportedly been a shift towards a rise in chronic illness since the mine was put into place (Rodriguez-Fernandez et al. 2015; Mensah et al. 2015; Fan et al. 2017; Mawaw et al. 2017; Wu et al. 2019; Dietler et al. 2021).

Furthermore, people who lived next to coal and gold mines were particularly worried about the consequences of the blasting, which left their homes with loud noises, terrifying vibrations, and

fissures. They also mentioned how afraid they were of dying when their fractured homes fell apart while people were inside sleeping. Also, studies mentioned a greater chance of accidents due to the increased traffic to and from the mine, especially for kids playing in the streets (Monir and Hossain 2012; Ismail et al. 2021; Leuenberger et al. 2021).

In addition, in the topic of soil and land, which was diversified in and of itself. Participants' primary worries were the deteriorating conditions for agriculture. They listed several causes, which they all connected to the mining project and their activities, including the land removed or their relocation, decreased accessibility or availability of their land, soil pollution, and decreased rainfall. Food quality issues and limited availability were also brought up concerning agriculture. Participants reported that this resulted in hunger as well as psychological stress from having to feed their families (Kosinskiy et al. 2019; Blanco et al. 2023).

Sanitation and hygiene were the final themes to emerge under the environmental consequences category. Because security personnel were not provided with restrooms, communities surrounding the mining fence reported instances of open defecation. Another issue was improper trash management. Maintaining hygienic conditions was seen as a significant concern, particularly in Burkina Faso, and was frequently mentioned concerning the health and well-being of adults and children. When considered collectively, environmental consequences were viewed as strongly detrimental and associated with many ailments, whereas better roads and water systems were seen as beneficial to the populations' health (Schwartz et al. 2021; Marwa and Sweya 2024).

Community and Social Level Factors

Some studies mentioned that mining workers and their families or communities were becoming less cohesive. For example, men left their families with their newly earned money or to look for other career prospects, and young people left their families to pursue education outside of the village. These relationships were also connected to a lack of trust in the community. More seriously, because there were more crimes in the locality, residents felt less safe (Wibisono and Ma'ruf 2021; Marwa and Sweya 2024).

Positively, participants expressed gratitude for the support given to community-based organisations, interest groups, and local associations. For instance, in Tanzania, the mine formed local vegetable farmer groups and provided financial help to beekeepers. One other unclear factor that was brought up has to do with schooling. Participants from all countries reported that the mining companies' new construction or better infrastructure in and around schools has boosted student attendance and the quality of instruction. However, it was noted that early school dropouts were more common in the vicinity of Tanzania's mines. Based on their interactions with mine workers, participants explained that this has an especially negative impact on girls when they become pregnant. It is interesting to note that whereas education was a theme of practically every discussion in Tanzania and Mozambique, it was discussed far less in Burkina Faso (Mactaggart et al. 2016c; Leuenberger et al. 2021).

Overall, several contexts shared measures aimed at enhancing social services including education and health care, which could lead to better community health. However, effects on the social organisations inside the communities were seen as detrimental to the general well-being of the populace, including several cultural elements unique to the nation.

Public Health and Policy Implications

Conflicting interests of the mining sector in rural areas are reflected in social injustice in mining communities, which is defined as unequal social distribution of benefits, burdens, and possibilities for life-changing outcomes (Morrice and Colagiuri 2013). According to Cheshire et al. (2014), the literature on HICs explains the rise of "meta-governance" in mine settings, because the local government, which is crucial to community development, must oversee and manage a relationship with influential mining enterprises. Public-private partnerships, or PPPs, are common in mine settings in low- and middle-income countries (LMICs). They demonstrate the resource sector's capacity to support social development and its interest in enhancing the lives of those who live close to mining activities. They also highlight the government's need for assistance in providing high-quality health services as well as increased financial and logistical input (Thomason and Hancock 2011). Through stakeholder involvement and communication, PPPs

are strengthened by gaining an understanding of the fundamental problems that a community has and the strategies that must be used to solve them.

The presence of mining activity close to communities could improve health and well-being and stop social inequality if it is properly managed and planned. According to an Australian study (Basu et al. 2015), proactive engagement between a mining company and the local community resulted in better investment outcomes in the regional economy, reduced antisocial behaviour, and enhanced community welfare initiatives and opportunities. According to Dupuy (2014), mining corporations have the option to collaborate with local agencies to enhance accessibility to specialised services or fund health promotion and awareness campaigns. Addressing the sustainable progress goals, among which are the goals of social progress, health, and well-being, should be a top priority for the corporate sector. Engaging with multiple stakeholders to ensure evidence-based and sustainable investments is crucial for the mining sector to effectively address cross-cutting challenges and make investments (World Economic Forum 2015). To guarantee that the demands of rural communities are not superseded by the powerful and lucrative mining industry, effective regulation, partnerships, and communication are essential.

According to the research, several interventions, and programs, particularly those about infectious illnesses and education, have been put in place in mining communities to address health-related challenges (Dawson and Homer 2013; Dupuy 2014). On the other hand, this review adds to the body of research supporting the notion that mine activity influences the determinants of broader health and well-being outcomes.

It is essential to consider the larger environment in which mining communities exist. This analysis uncovered the complex, systemic elements influencing results and emphasised the necessity of a strategy that considers social determinants of health and the location of mining operations in areas frequently marked by destitution, joblessness, and a lack of resources. Traditional health impact assessments or baseline studies cannot be used to establish the mid and longer-term effects of mining on communities. Monitoring and responding to these impacts is relevant in enabling sustainable development beyond the mine's lifecycle. In mine settings, the use of health needs assessments and other community-based instruments that measure health conditions using the social determinants of health framework is becoming increasingly prevalent (Smith et al. 2010; Korfmacher et al. 2014). Indicators of both individual and community well-being ought to be included in community assessments of the effects of mining. A stronger emphasis on creating instruments with wider viewpoints to evaluate impacts and results is required to accomplish the aims of the Sustainable Development Goals (United Nations 2015).

CONCLUSION

This review showed that even though communities frequently coexisted with a variety of mine activity types and stages, similar patterns of health or well-being outcomes were reported to be linked to the impact of mining on public health in general, such as the existing of communicable and non-communicable diseases, effect on the environment, economics, and the sociopolitical environment. Population health and well-being are closely related to economic growth, and the mining industry's dedication to long-term, evidence-based, socially responsible practices is essential to maintaining this growth.

RECOMMENDATIONS

The push for better legislation requiring mining companies to mitigate social, environmental, and health impacts, the responsibility of governments to ensure sustainable development of their communities, and the involvement of scientific researchers in strengthening the evidence base all point to an increasing international focus on the longer-term, indirect health impacts of mining on nearby communities in mineral-rich countries.

Governments play a crucial role in addressing the requirements of communities for health and well-being through efficient policymaking and resource allocation. They oversee enacting laws, keeping an eye on, and regulating social and cultural challenges resulting from mining. This review emphasised the need for thorough and open monitoring of the effects of mining on public health, with an emphasis on the gendered effects and consequences for mental health.

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CONSENT FOR PUBLICATION

Not applicable

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RA, SP, RAY and YT developed the initial concept and idea. RA, SP, RAY and DAM conducted literature searches and prepared the initial manuscript. RA made critical revisions and prepared the final submitted manuscript. RA, AD, ABB, RAY, DAM, and AS reviewed the work and provided further revisions. All contributing authors have approved the final draft.

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