Occupational Mining Exposure and Its Intergenerational Effects on Parental Health and Children's Educational Well-Being in Kolar Gold Fields: A Review

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ABSTRACT:
Active mining has left long-term health, social and education impacts on the people of Kolar Gold Fields which far outweigh the time they were actually working in the mines. This review begins by investigating the impact on the respiratory, musculoskeletal, psychological and functional health of workers from prolonged exposure to respirable silica, heat, noise, vibration, toxic materials and physically demanding work, and how that can be passed on to their families. Chronic illness and disability can lead to decreased livelihood and productivity, higher treatment costs, changed care roles, and diminished household security. Children can thus be affected by a lack of food security, stress, poor access to learning, absenteeism, shortened learning time, burden of child care responsibilities and pressures to enter paid labour. Resilience and educational continuity are also identified as outcomes that are influenced by effective exposure control, early diagnosis, chronic disease management, income protection, balanced care taking, supportive schools and accessible welfare services. From the mining environment, evidence has emerged that highlights the need to reduce the silica content of dust, screen for silicosis and tuberculosis, screen for heat, toxicological and other risks, as well as for continued respiratory follow-up. This coordinated action is essential both within occupational health services, and between the different sectors of the school, the labour authorities, welfare agencies, social workers and community organisations, in order to protect affected households. Providing a range of services for children's attendance, participation, progression and aspirations including health and compensation, rehabilitation, psychosocial support, nutrition and educational assistance. The illness among parents related to the mining activity should, therefore, be considered as a persistent issue in the family, school and public health arena in Kolar Gold Fields from generation to generation and community to community.

Keywords: occupational mining exposure, parental health, educational continuity, intergenerational effects, Kolar Gold Fields

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1. Introduction

In numerous mineral producing areas, mining activities have been vital for the development of industries, jobs and the livelihoods of the households. However, the economic value that it provides has significant occupational, environmental, and social costs. Respirable crystalline silica, mineral dust, toxic materials, excessive noise, heat, vibration, poor ventilation, physical strain and underground accidents are hazards that may be encountered in the mines. The risk from these exposures is to the lungs and breathing system, chronic pain, disability, and mental stress, and can persist long after people have stopped working. Parental poor health can have effects beyond the worker and impact family income, child care, family stability, and children's education.

This is an important context in which to explore these interrelated outcomes, as is the case with Kolar Gold Fields in the State of Karnataka. The gold industry had a significant influence on the economic, settlement, labour relations and community identity of the region for over 100 years. The mining industry provided a livelihood for generations of families directly and indirectly and grew into towns and services. But with the demise and closure of the big mines this structure was upset and the former miners and their families had to deal with the lack of jobs, lower income, work-related illness, aging and poor access to alternative livelihoods. Other gold-mining regions provide evidence of how mining can benefit the rural livelihoods, and how it can also cause uncertainty about the economy and dependence on unpredictable extractive work over the long term (Adranyi et al., 2023). These are very relevant to Kolar Gold Fields as their impact on the health of parents and household living conditions could persist.

Since its time the worst hazard of mining is still respirable crystalline silica. Fine particles can reach the deep lung tissue and cause inflammation, fibrosis, lung dysfunction and silicosis. Can persist post exposure and make people more susceptible to TB and other lung diseases. Silicosis was observed in a cohort of metal and non-metal miners from the western United States from 2002 to 2023, indicating that silica-related disease is an ongoing occupational problem (Zell-Baran et al., 2024). The results of the work performed under the Miner Act also demonstrated the need for dust monitoring, engineering controls, regulatory enforcement, respiratory protection, and medical surveillance to effectively prevent exposure (Luxbacher & Reed, 2022). Exposure might have ended in these communities, but the health consequences continue to affect older workers, especially in the past mining towns.

There are other health effects of mining besides silicosis. Ears, joints and tendons, energy and endurance, heart and blood vessels, nervous system, psychological stress and depression can all be affected by the work. Low and middle income countries face a heightened risk of such exposures, due to poor monitoring, poor enforcement of safety measures, poor protective equipment, and poor access to occupational health care services. Previous scoping reviews revealed a lack of consistency regarding evidence of exposure intensity, health surveillance, and protection at the workplace, in addition to multiple and overlapping exposures among workers in these settings (Quintero Santofimio et al., 2024). Other factors that influence the safety performance of the workers are organisational culture, training, worker participation, commitment to regulations, and practical risk control (Milošević et al., 2025). The concept of a safe and healthy working environment should therefore be considered to be a basic labour right that is associated with public health, social protection and sustainable development (Özgür, 2026).

When parents become ill due to their work, it can impact family income, child care responsibilities, and educational opportunities, making the situation more serious. Having a parent with chronic respiratory illness, disability or mental health problems could make employment and/or responsibilities for supervising children and supporting schoolwork more difficult, as well as

make it harder for parents to communicate with school staff and maintain a consistent family schedule. Costs associated with health care can be in competition with book, transport, food, school and electronic learning costs. Children might have chores, look after an unwell parent, be employed or have to leave school during times of family tragedy. Child labour is linked to poverty, potential health hazards, stunted growth and fewer education opportunities in mining communities (Bansah & Adonteng-Kissi, 2025). It has been estimated that 138 million children are engaged in child labour, but this figure does not reflect the situation if unpaid domestic work and intensive care-taking are taken into account (Verhulst-Georgoulis et al., 2026).

School enrolment is only part of an educational well-being. It is made up of regular attendance, concentration, emotional security, participation in the classroom, academic progression, access to learning resources and the opportunity to further education when there is family instability. Parental illness, poverty and insecure livelihood, unsafe environment and limited institutional support in the mining communities are a source of stress for children. These pressures can have a negative impact on motivation, study habits, education expectations and drop-out or absenteeism rates. Coping and resilience can be bolstered through economic support, health care access, counselling, community networks, and sustained support to keep children engaged in school; however, there is limited and inconsistent evidence of the long-term effectiveness of these interventions in the mining regions (Chidwick et al., 2023).

literature has tended to focus on the health of the miners, change of livelihood, child labour, adolescent resilience, and disruption of education separately. Few studies have examined the links between parental occupation exposures, chronic illness, household functioning and children's educational experiences in post-mining communities. Even in the region which has a long history of mining and has ongoing health and social issues related to mining, evidence is still dispersed. Hence this review delves into occupational exposure to mining and its intergenerational consequences on parental health and child educational outcomes in Kolar Gold Fields. It combines data from the occupational hazards, chronic parental illness, household strain, interruption in parental care, school involvement, and educational continuity. The review highlights the potential for the effects of mining to be passed down through generations, through family dynamics and familial resources, children's schooling experiences, and the opportunities available to their children.

2. Mining Exposure and Socioeconomic Conditions in Kolar Gold Fields

Kolar Gold Fields has a unique contribution to make to the Indian industrial and labour history. Gold mining had a major influence on the economy, settlement patterns, employment structure and community identity of the area for over a century. The mining industry employed thousands of people and surrounding it were caravan towns, schools, hospitals, buses and railways, and markets. The close interdependence of households was closely linked to the continuity of employment in mining. If the production went down and the big factories shut down, the consequences were felt beyond the workplace. Facing unemployment, poor wages, occupational illness, and an inability to work in other jobs, former miners and their families were at risk of ageing, ill health, and being out of work.

Underground mining posed a number of dangers, which frequently happened at the same time. The lack of fresh air and high dust levels was more pronounced in deeper parts of the mines because of poor ventilation. The process of drilling, blasting, crushing, and/or transporting rock that contained minerals created dust consisting of particles that could enter the respiratory system, containing silica. Respirable crystalline silica is especially dangerous because the particles get deep into the lungs where they can cause inflammation, scarring and gradual decline in lung function. Exposure conditions in metal and non-metal mines are particularly complicated due

to the toxic effects of silica dust (Siahidouzazar et al., 2025) which depends on particle size, surface activity, mineral composition and the process by which silica dust is produced. Mixed mineral dust has been estimated to have exposed workers to risk for a long period of time in Kolar Gold Fields, underground, where the risks may have persisted when the workers were no longer employed.

High noise level, vibration of machines, excessive heat, restricted working area, repeated movement and constant physical effort were also included. The risk of falls, explosions, collapse of the tunnels, injury from equipment and exposure to potentially hazardous substances was also a risk to workers. Continuous, repetitive lifting, bending, climbing and working in awkward positions may lead to chronic musculoskeletal pain and a decrease in mobility. Typically these hazards did not exist in isolation. A miner might also be exposed to dust while working at other jobs that involve loud noise, heat, and psychological stress—the all three conditions can lead to a variety of chronic health issues. In California, silicosis was found to be on the rise from 2019 to 2024, even when formal safety controls and health-care systems are present (Flattery et al., 2025).

The impact of the work exposure became more apparent after the person retired, became disabled, or left the mine. Former miners may find that chronic respiratory disease, hearing impairment, physical weakness, and decreased mobility, may make it impossible for them to work in other occupations. With a lower earning potential, medical expenses were more often higher, putting a strain on households' finances. The families of no longer had their regular earning from the mines but now had to depend on informal work, pensions, remittances, borrowing or the income of younger members of the family. Some working age adults migrated to work, others stayed due to caregiving duties, property ties or poor mobility. These changes may lead to disintegration of the families and less time and resources available for children's education.

Wider local economy was also affected by closure of the mines. Lost customers and income for businesses, transport services and informal occupations related to mining. Neighbourhood markets, house maintenance, healthcare services and community services were impacted. If a household is already coping with a health condition or a disability, a decrease in income may create challenges in finding adequate housing, food, medications and routine medical visits. Labour and welfare policies play a key role in such conditions as they define compensation, social security, recognition of occupational disease, and rehabilitation, which will ensure that affected families are adequately supported if they are affected. The focus of labour policies in India remains on protecting workers' interest and workers' welfare but implementation issues can render the worker and the dependent workers helpless when it comes to getting help after the mining days are over (Yojana, 2024).

The occupational health institution must be strong to ensure long-term disease identification, recording of exposure and providing direction for prevention. With weak surveillance systems, silicosis and other respiratory diseases can go undiagnosed or mistaken for other diseases. This means that there is a lower probability that they will receive timely treatment, compensation and legal recognition. As occupational-health institutions weaken at the national level, Cummings and Harrison (2025) caution, so can the institutions' ability to provide disease surveillance, scientific guidance, and respiratory protection. This is a very strong concern in post mining areas like Kolar Gold Fields where the exposure may have taken place decades ago, but the health impacts are continuing to affect the former miners and their families.

These work and socio-economic burdens have a direct impact on children's educational circumstances. Household income can decrease, which can lead to lower spending on school fees, books, uniforms, school transportation, school tuition, digital devices, and Internet. In addition to the costs of education, medical costs can be prioritized over education and migration or

unstable accommodation can affect attendance and continuity of learning. A parent's disability or illness can also cause children to take on domestic and/or care responsibilities, which affects study and school participation. The lack of adequate nutrition, stress within the family and uncertainty over family income can also have an impact on students' concentration, motivation and academic progress.

Going from school to higher education can be a challenge for children of mining affected families. While a strong focus has been laid on ensuring access and participation in higher education in India, factors such as economic stress, lack of access to digital resources, and financial support from families still have an impact on the ability of students to stay in school (Misra & Sabharwal, 2025). Occupational illness, unemployment, migration and a decrease in the household income can thus limit immediate attendance at educational institutions as well as future mobility of students in the education system in Kolar Gold Fields. The social and economic repercussions of the mining activity are thus not limited to the past miners. It extends from the familial, from the home, the children's education, and the educational opportunities of the next generation.

3. Occupational Mining Exposure and Long-Term Parental Health Outcomes

Exposure in the workplace may cause health impacts that occur while on the job and continue after retirement. Respirable mineral dust, crystalline silica, toxic dust, noise and vibration, heat, inadequate ventilation, physical strain and risk of accidents are all common exposures that miners face. Together they can harm respiratory, auditory, musculoskeletal, cardiovascular and psychological health, resulting in a burden which is also felt in the worker's/employee's family. Many of the old miners in Kolar Gold Fields could still be suffering from chronic diseases associated with their time underground for many years.

One of the most severe impacts of mining is respiratory disease. Exposure to fine mineral dust may lead to chronic cough, shortness of breath, deterioration of lung function and disability over time. The worst thing about silicosis is that the crystalline silica particles enter lung tissue and cause inflammation and scaring that can't be repaired. The disease can progress following exposure and may make one more susceptible to TB. The decrease in respiratory capacity can limit mobility, endurance and . . . These restrictions can lead to reliance on the spouse and children, and to family assuming the responsibilities of care.

Mining also has other impacts than on the lungs. Drilling, blasting and heavy machinery operations may cause permanent hearing loss and tinnitus if they are frequent and continuous. Chronic back pain, joint disorders, muscular weakness, and decreased mobility can be caused by repetitive lifting, bending, climbing, and working in confined spaces. Rock falls, machinery failure and explosions can result in permanent impairment. Cardiovascular strain can occur from sustained physical activity, hot temperatures, exertion and fatigue, and stress. If conditions happen together, miners could suffer from a combination of ailments.

Table 1. Occupational Mining Exposure and Intergenerational Educational Effects

Analytical domain	Key conditions or outcomes	Implications for family and education
Occupational exposure	Silica dust, noise, heat, vibration, toxic substances, and accident risks	Increased likelihood of chronic occupational illness
Parental health	Respiratory disease, hearing loss, chronic pain, disability, and psychological distress	Reduced employment, mobility, caregiving, and parental support

Household impact	Income loss, medical expenses, debt, and migration	Lower capacity to support nutrition, healthcare, and schooling
Educational effects	Irregular attendance, poor concentration, and weaker academic performance	Disrupted learning and reduced educational continuity
Long-term consequences	Lower educational attainment and limited progression	Restricted future opportunities and continuing family hardship

Table 1 illustrates how the effects of occupational mining exposure may impact on a child's education indirectly, by impacting the health of the parents, the family's income, the capacity of parents to care for the child and the child's ability to attend school or complete their studies.

Good mental health is a big issue. The fear, uncertainty, exhaustion and dangerous events are often associated with mining work. Those who suffer an accident, injury, loss of employment or diminished physical abilities can become anxious, depressed, feel disturbed, irritable or diminished physical purpose. These can be exacerbated by the effects of mine closure, which can deprive people of a sense of place, livelihood and income. The health and well-being of individuals and communities is influenced throughout the mine life cycle – from mining, closure, and post mining (Pieters et al., 2025).

The extent of these outcomes is related to protection at work. Poor protective equipment, inadequate safety training, medical surveillance and emergency systems increase the risk of chronic disease and injury for miners. Let's look at what evidence tells us about the risks to workers in artisanal and small-scale mining in South Africa: There is an increased risk of workers being vulnerable due to inadequate safety measures, limited training, unsafe environments and poor access to occupational healthcare.A review of evidence reveals that workers are vulnerable to inadequate safety measures, lack of training, unsafe conditions and poor access to occupational health care in artisanal and small-scale mining in South Africa (Rose & Allen-Spies, 2023). They are also a concern at Kolar Gold Fields as many illnesses may have been underdiagnosed, poorly recorded or not compensated for.

Parents who are sick for an extended period of time will affect the family's economic and emotional fabric. A miner with a chronic health condition like respiratory disease, loss of hearing, chronic pain or disability may not be able to return to work. The consequences of reduced income can occur at a time when expenses for medical care increase, putting financial strain on the household. Illness may also restrict parents' ability to move around, make decisions and participate in activities. In cases of anxiety, depression or physical fatigue, parents may struggle to monitor study, get in touch with teachers or offer emotional or academic support.

All of these changes may have an impact on children's learning health. Less family income could lead to a decrease in family spending on school clothes, books, transportation, tuition fees, digital devices, and Internet access. Parents who fall sick or get disabled can also be given domestic duties or care-taking responsibilities by children, which may interfere with their study, and further be interruptive in attendance. There is a close link between health and income, health and education and the social opportunity (United Nations Development Programme, 2023). These pressures can be mitigated through employment, rehabilitation, compensation, social protection and community support, as well as through the development-oriented local content measures that can increase skills and household security (Alokalaro et al., 2024). There is a risk of exacerbating inequities if access to education technology is uneven (Antoninis et al., 2023).

The main route by which occupational exposure to mining results in the next generation is through parents' health. Chronic illness has a negative impact on workers' bodies, income, care giving, family relationships, household decisions and educational investments. The individual and long term health impacts of mining must be viewed as a family and educational issue as they can be felt through the attendance, participation, achievement and future opportunities of children.

4. Intergenerational Pathways of Health, Stress, and Family Vulnerability

The impacts of occupational exposure to mining can extend to children's generations through complex biological, socioeconomic and psychosocial pathways. The burden starts with the contact of the miner with the toxic particles, silica dust, noise, heat, vibration, physical strain and risk of accidents. The hazards can cause lung disease, silicosis, and a decrease in lung function, injury, pain, and psychological stress. When examining family effects, cumulative occupational burden is crucial because health outcomes for miners are not solely driven by single exposures and there is a need for interaction among risk factors (Zhang et al., 2024). An illness among parents can thus be the root of family dysfunction and disrupted childhood conditions.

Biological pathways can be in place pre- or early-natally. Exposure to mineral dust and toxic materials for a prolonged period may impact reproductive health, maternal health and pregnancy status. Developmental vulnerability may arise from poor maternal health, respiratory strain, nutritional deficiencies and sub-optimal antenatal care. Household contamination can also occur after work when dust is transferred from work to shoes, clothes, tools or skin. Children can then inhale the leftover particles in their own homes or close to their home. Effective exposure control is the only way to prevent silica-related disease, since fine respirable particles can pose a danger even if not visible (World Health Organization, 2025). If prevention and monitoring are not effective, risk can outlast the workplace and intrude into family spaces in the local area. Parental mining exposure can affect children's education in three ways: health, economic and psychosocial. (Figure 1).

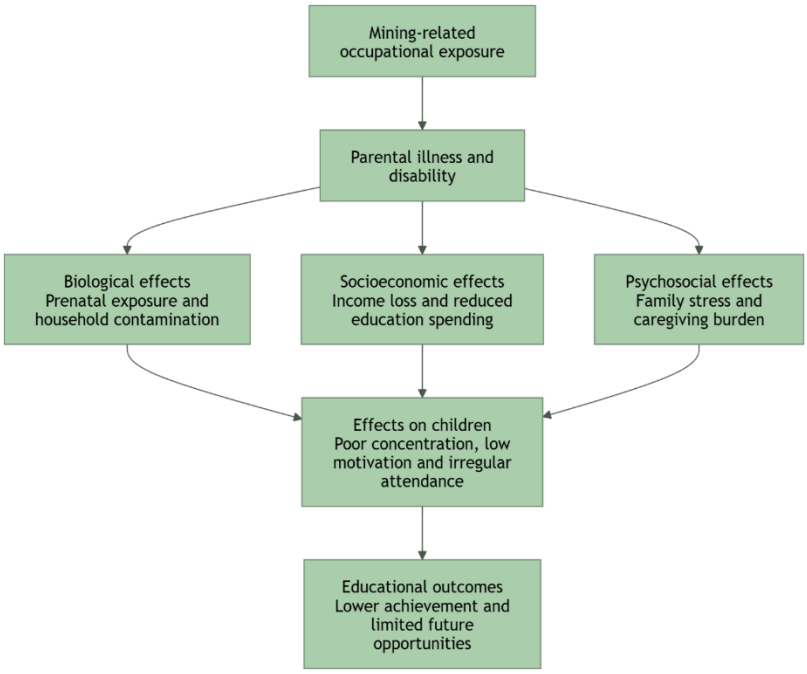

Figure 1. Intergenerational Effects of Mining Exposure on Children's Education

Food chains are also important. A chronic illness of parents may decline their earning potential and may lead to an increase in parent spending on diagnosis, medication, travel and treatment. Household resources will become tight and families may cut back on buying 'good food', medical care and children's needs. Food insecurity can have an impact on physical growth, energy levels, school readiness and cognition. Well-nourished children are more alert, more able to concentrate, more cheerful and better able to learn.Nutrient children are energetic, they can concentrate better, they are more cheerful and better in learning. The impact of these factors may be amplified where there is a combination of ill health, unemployment and unstable housing, which can lead to a vicious circle of health problems and educational difficulties.

Socioeconomic transmission is sometimes expressed by losses in income, debts, and decreases in investment in education. Parents with disability, chronic pain and/or silicosis may not be able to work in the same capacity as before. School fees, school uniforms, books, school transport, tuition, digital devices, Internet access and even tuition may then be competing with medical costs. Families are able to borrow, sell property or move, or rely on informal employment. Migration may disrupt attendance and continuity of learning and insecure housing can restrict access to quiet learning areas and continuous schooling. Evidence regarding respirable crystalline silica has highlighted the importance of continued efforts to prevent exposure, monitor, and provide institutional protection as the costs of health and economic impacts may be higher for affected households if exposure is not recognised until later (Luxbacher & Reed, 2022).

Another level of vulnerability is added with psychosocial pathways. Parents might have to assume new roles when they have a chronic illness, they may be less emotionally available, and there may be more stress within the family. For parents experiencing pain, breathlessness, anxiety or depression, it may be difficult to provide supervision or to be consistent with children and their teachers. Children could be concerned about their parents' lives, the household income, the stigma of the disease or poverty, and financial difficulties and conflict. Some may find themselves in caregiver or domestic jobs or in income generation. These duties can decrease study time, diminish motivation and can lead to poor attendance.

Enrolment in itself doesn't contribute to educational persistence. Children look to emotional security, attending regularly, having access to learning materials, supportive adults and confidence in the future for opportunities to support them. UNICEF's approach to education prioritises ongoing support for children and adolescents to learn, develop skills and stay in school in the face of precarious family dynamics (United Nations Children's Fund, 2024). For mining-affected families, a number of factors disrupt educational progress, including parental ill health, lower income, responsibilities for childcare and stress.

Intergenerational effects, then, appear as a cumulative process, rather than a one-off occurrence. All of the above can interact with and impact child development, attention, behaviour, motivation and school attendance. In Kolar Gold Fields the pathways focus on how harm suffered by parents can extend into the education of their children. The link between the workplace and the wellbeing of the family, children and their education needs for the future is important and requires an understanding of this relationship.

5. Children’s Educational Well-Being in Mining-Affected Households

Parental health, income, care responsibilities, nutrition, emotional security and access to learning resources are all factors that impact children's learning and wellbeing in mining-affected households. It is not just about enrollment, it's about attendance, being on time, participating in the classroom, achieving, advancing, motivation, retention, and continuing to learn when the family is in crisis. These dimensions can be diminished over time within communities where there are issues arising from

occupational illness or where a community is experiencing a decline after mining.

The first place where occupational harm can enter into a child's learning environment is when parents fall ill. Parental chronic respiratory illness, disability, pain, fatigue or psychological distress may diminish a parent's capacity to work, supervise homework, attend school meetings, or to keep regular routines. Medical treatment, medical travel and lost income can cause the household to shift its funds away from books, uniforms, transport, tuition and examination fees, and digital resources. The health impacts of mining-related occupational and toxicological exposures can persist long after the miners have retired from the workforce, and result in dependency in the household and reduced capacity of parents to engage in their children's education (Brown et al., 2024).

Household poverty may have an adverse impact on the continuity of education. Learning materials, school transportation and digital devices can be a financial burden for the families. Children might miss school if transport becomes too expensive, or if there is a greater need for them to take care of domestic affairs. Others may become involved in informal work, look after their younger brothers and sisters or provide for a sick or elderly parent. These duties will demand time from studying and will generate a sense of fatigue and hinder punctuality. The outcomes can be: Lack of completion, poor engagement, substandard performance, grade repetition and early school drop-out.

Education participation is affected by nutrition. Poor nutrition could be the result of a reduction in income, which could make it difficult for children to concentrate, be distracted, and/or physically exhausted. Nutrition deficits impact attention span, memory, participation in class and task completion. Such challenges can be perceived as a lack of motivation even in the context of household factors. The occupational syndemics that affect miners demonstrate the synergy of disease with poverty, social stress and poor access to services, and the combined impact of these factors is greater than any individual factor (Bulled & Singer, 2024). Children could also be impacted by a similar interaction when parents are sick, the family has no food security, parents experience stress, and they have little educational support. Important educational pathways that influence children's educational well-being in mining-affected households are the interactions between health, economic, caregiving, nutritional, emotional, digital, and demographic pathways (see Table 2).

Table 2. Determinants of Educational Well-Being in Mining-Affected Households

Determinant	Pathway	Educational outcome
Parental illness	Reduced supervision and emotional support	Irregular attendance and weak engagement
Income loss	Limited access to learning resources	Interrupted learning and slower progression
Caregiving duties	Reduced study time and increased fatigue	Poor concentration and incomplete schoolwork
Nutritional insecurity	Low energy and weak cognitive readiness	Lower participation and achievement
Emotional distress	Anxiety, withdrawal, and low confidence	Reduced motivation and aspirations
Digital exclusion	Limited devices, connectivity, and online support	Wider learning gaps

Gender and age pressures	Unequal domestic and earning responsibilities	Higher absenteeism and dropout risk

Learning is also impacted by emotional well-being. Children might be scared of the disease of their parent, anxious about the income, embarrassed of poverty, or uncertain caused by the closure of mines. This can lead to lack of confidence, irritability, withdrawal from other people and activities, decreased concentration, and decreased motivation. Younger children may get into difficulties with routine, and older children (teenagers) may be under pressure to work, move or drop out of education. The interruption of study programmes and less supervision may take an additional toll on progress and aspiration.

Access to digital has become a key component of participation in education. Technology can be used as a means to aid in communication, exam preparation and access to educational materials. However, it can exacerbate inequality if there are unequal access to devices and connections, and to adult guidance. Mining-affected children might have to share one device, have poor internet connectivity or lack support to access online learning. While technology can enhance learning, its impact is not guaranteed, and can potentially further marginalize those with limited access to or support for technology (Antoninis et al., 2023).

Intra-household diversity also needs to be accounted for among households impacted by mining. The domestic/work roles of boys and girls can be unequal in some cases, and boys can put more pressure on each other to take up paid employment.Domestic/Work roles of boys and girls may be unequal in some cases, and boys may bring more pressure on themselves to take up paid work. Younger children might need some parental supervision while older children might be expected to contribute some income. Other factors like family income, parents' professions, seriousness of the disease and migration experience also influence outcomes. The importance of children and youth learning and developing skills even in the face of economic shifts is highlighted by global education priorities (Annual, 2024).

Whether children have the hope, confidence and progression to maintain in the face of uncertainty is important for their long-term educational wellbeing. It is important to consider children in the context of a changing future for childhood, where a children's home environment is likely to be disrupted by economic disruption, environmental risk, and reduced social protection (Herbst, 2024). Parental illness, decreased income, childcare burdens, poor nutrition and emotional stress can all be interlinked and have an impact on attendance, achievement, retention and future mobility in Kolar Gold Fields. So it is important to focus on factors influencing children's capacity to be engaged, supported and hopeful in their school-going journeys if children's education is to be protected.

6. Determinants of Resilience and Educational Continuity in Mining-Affected Households

The existence of mining related illness and economic hardship can influence resilience and educational continuity if families are unable to maintain health, income, caregiving, emotional stability and opportunities to learn during these periods. These are more significant in Kolar Gold Fields, wherein the impact of mining activities can be felt even after one has retired. Former miners may suffer from impaired health of the respiratory system, decreased mobility, chronic pain, and lower productivity, and their families face the expenses of treatment, loss of income, and increased family responsibilities. These pressures should be counterbalanced by good exposure control, prompt medical care, sustainable livelihoods, positive family dynamics, responsive schools and available welfare services, all of which provide children with protection of their education.

Prevention is always the first line of defense. Small-scale tanzanite mining has demonstrated that when practical measures are implemented and maintained to control exposure to RCS, it is technically possible to achieve a reduction in exposure levels (Nota et al., 2024). This has direct implications for resilience of the household as it can lower the likelihood of developing severe work-related illness, maintain the capacity of the worker to work, and decrease future reliance on family members. Prevention measures for exposure should involve dust suppression, good ventilation, safer drilling methods, maintenance of equipment, personal protection, training of workers, and periodic monitoring. If the preventive systems are not strong, the health burden is shifted from the workplace to the home and manifests as disability, medical costs and decreased parental involvement in children's daily learning. Table 3 outlines the key household and institutional factors that underpin resilience and continuity of education in the mining-affected families.

Table 3. Key Determinants of Resilience and Educational Continuity

Determinant	Household effect	Educational implication
Exposure control	Reduces occupational illness and disability	Preserves parental support for schooling
Disease management	Limits respiratory decline and treatment burden	Reduces disruption to attendance and study routines
Economic security	Protects household spending capacity	Maintains access to books, transport, nutrition, and digital resources
Balanced caregiving	Prevents excessive domestic and earning duties among children	Protects study time and regular attendance
School support	Identifies absenteeism and learning difficulties early	Improves participation, retention, and progression
Community support	Improves access to healthcare, welfare, and compensation	Strengthens educational continuity

The long-term management of the disease is also crucial. Artisanal miners and small-scale miners who are exposed to silica for extended periods often also have a history of tuberculosis, and the interplay between the two can have a significant impact on their respiratory health and ability to earn a living (Howlett et al., 2023). For miners' families, when a diagnosis takes too long, it can worsen both health and educational issues. Preventing functional decline involves regular screening, access to respiratory care, testing, treatment follow-up for TB and rehabilitation. Another way these services help children is by helping to reduce unexpected income loss, emergency medical expenses, and parental participation in school activities, supervision, and emotional support.

Economic stability impacts family's ability to continue investing in education when sick. Housing units that have pensions, compensation, savings, another job or social assistance better have the means to spend on books, transportation, uniforms, nutrition, and digital access. If a family doesn't have the support, they can borrow or sell assets, delay treatment or rely on children's labour. Responsibilities for caregiving might be not be equal. Girls can be expected to take up domestic and care roles, boys can be expected to be pressured into paid activities. One of the main concerns is that adolescents are particularly vulnerable, as they might be used as substitutes for adults when earning income. These changes can lead to

decreased studying times, fatigue and lower levels of attendance.

Schools play a pivotal part in the continuity of education. The findings from the mining communities in the Democratic Republic of the Congo indicate that school attendance is significantly associated with hazardous and non-hazardous activities that children engage in, highlighting the potential of the education system to either increase or decrease vulnerability (Mihigo et al., 2024). In Kolar Gold Fields, attendance monitoring, counselling, remedial teaching, provision of transport facilities, scholarships, flexible deadlines and frequent communication with families are avenues through which early support can be provided in schools. These steps can help stave off temporary disengagement from becoming long-term disengagement or drop-out.

Community and institutional support enhance resilience. Access to healthcare, compensation, legal protection, and social security are among the challenges faced by mining workers, highlighting the importance of social-work intervention (Sahoo & Rout, 2023). They can support families to get medical referrals, disability certification, pension payments, counselling, food assistance, and education assistance from social workers, health professionals, schools, local authorities, former miners' associations and welfare agencies. They help households coordinate so as to lessen the workload on the household and facilitate access to entitlements.

In Kolar Gold Fields, a resilience-based approach should consider the health of the miners and the education of children as related aspects of the well-being of the household/community.

The overall effectiveness of prevention, health, income protection, balanced caregiving, school support, and community support for educational continuity in mining-affected households depends on the synergies between these elements.The overall effectiveness of the prevention, healthcare, income protection, balanced caregiving, school support and community assistance for educational continuity in mining-affected households depends on how these elements work together. These factors don't function independently. Families can better maintain the attendance, participation, progression and aspirations of children when there are multiple. In the absence of such, an occupational illness may continue to impact the next generation through reoccurring educational disruption and opportunity loss.

7. Multisectoral Strategies for Protecting Family Health and Children's Education

Coordinated and joint action between the four areas of occupational health, clinical care, social protection, education and community support is needed to ensure that family health and children's education are protected in the mining affected communities. The impact of mining on Kolar Gold Fields is manifested by chronic ailments among the retired miners, diminished income potential, stress of care taking, food insecurity in the household and disruption in schooling of children. The challenge of occupational exposure requires a multisectoral response as no single institution is able to handle the medical, economic, social and educational consequences of exposure. Health services, schools, labour authorities, welfare agencies and community organisations need to be linked together into referral and support systems instead of function as independent programmes.

The response should be based on an integrated respiratory surveillance. These factors are the interaction between silica exposure, silicosis, tuberculosis infection, late diagnosis and restricted access to occupational health care services and are reflected in silicotuberculosis. A scoping review of miners' evidence reveals that risk is influenced by several occupational and clinical factors, underscoring the importance of multiple screening, as opposed to single disease-specific screenings (Saliba et al., 2025). Kolar Gold Fields: occupational histories and assessment of symptoms, TB testing, chest evaluation, lung-function testing, and long-term follow-up of ex-miners. Accessibility of exposure and disease records would also help to ensure

continuity of treatment, recognition of occupational illness, and access to compensation.

There is a need to factor in heat-related risk into occupational/community health planning. The work environment in a mining operation can be hot, physically demanding, and poorly ventilated, can cause dehydration, and can involve long shifts. These can lead to fatigue, poor decision-making, injury and acute and chronic sickness (Taggart et al., 2024). Protection should be based on a heat-risk assessment, availability of safe drinking water, planned rest breaks, ventilation, acclimatisation, appropriate clothing and educating workers on protection. While large scale mining operations have been suspended in Kolar Gold Fields, these measures are relevant when evaluating the impact of past mining activities, rehabilitating affected mine workers, and ensuring the safety of workers involved in other extractive or industrial operations that are connected.

Also less obvious environmental and toxicological risks need to be monitored. Artisanal gold mining (AGM) is an activity where naturally occurring radioactive materials (NORM) are a potential occupational exposure risk, research in the artisanal gold mining regions showed that the evaluation of the occupational exposure can be done by deterministic and probabilistic health risk assessment approaches (Emumejaye et al., 2025). This evidence can aid in environmental sampling, task-based exposure assessment and clear risk communication in mining impacted communities. Systematic testing of soil, dust, waste materials and the environment of homes in Kolar Gold Fields could aid in determining if exposure to these hazards is occurring outside of work. Medical surveillance, remediation of the environment, and protection of the household should be linked in each instance of detected risk.

For miners with past TB or silicosis, or for those who still have some residual impairment of the lungs, long-term care is very necessary. History of TB may have future effect on later spirometry results, suggesting that past infection may continue to influence respiratory function and clinical interpretation of spirometry amongst miners (Mtei et al., 2026). Single medical camps are thus not enough. Former employees need to be reassessed for their lungs, treated, reminded to take medications, be referred to pulmonary rehabilitation, and have functional capacity monitored. More effective management of disease can help keep people independent, lower emergency medical costs and help prevent the shift of care responsibilities to spouses and children.

Medical protection needs to be coupled with economic and educational support. Parental sickness can lead to a decrease in family income and thus a decrease in food, transportation, books, tuition, uniforms and digital access. Pupils who are absent from school repeatedly, in distress, doing worse and/or taking on excessive care giving responsibilities should be identified. Attendance and progression can be maintained through counselling, remedial instruction, scholarship, provision of meals, flexibility of deadlines, and regular contact with parents/guardians. Health and labour departments should put in place referral systems whereby workers are identified as having an occupational illness and then assessed for compensation, disability benefits, livelihood support and for education benefits to the dependants.

The work of community organisations, such as former miners' associations, healthcare workers, teachers and social workers, can help families to manage documentation, treatment, pensions, welfare entitlements, and school support to enhance access to these services. Services need to be delivered on time and in a coordinated fashion for a multisectoral approach to work. In Kolar Gold Fields, child education protection is the last thing that can be achieved unless the occupational illness of the child's parents is seen as a continuous family, social and public health problem whose impact on child education can be observed across generations over time.

8. Conclusion

The effect of mining activities at Kolar Gold Fields has been so far-reaching that it has affected not only its working days but also the future. Earlier, the exposure to silica dust, heat, noise, vibration and toxic substances etc. and physically challenging work environment has led to chronic health issues for miners in their respiratory, musculoskeletal, psychological and functional health. These impacts on the quality of life are manifested in the family through diminished earning potential, treatment costs, care needs, emotional stress and household insecurity. Children may have challenges with school attendance, attention and focus, limited access to learning materials, nutritional insecurity, greater responsibility at home, and pressure to work due to which they might not be able to progress through education or move to a different location. The review demonstrates that intergenerational effects occur via a combination of pathways – connected health, economic, psychosocial and educational – and not via one pathway alone. Early diagnosis, long-term disease management, stable income, balance of caring, supportive relationships, school connectedness, and community involvement are important to family resilience. Protective action is thus only effective if it is coordinated between the occupational health services, hospitals, schools, labour authorities, welfare agencies, social workers and organizations. These measures such as respiratory surveillance, follow up of TB, rehabilitation, compensation, livelihood support, counselling, nutrition support, scholarships, transport, remedial teaching, and attendance monitoring should be integrated. For addressing the mining legacy in Kolar Gold Fields, it is important that the illness of the child's parents is an ongoing family and public-health issue. Maintaining the education of affected children and the health of children and young people while ensuring that affected workers are protected, will contribute to strengthening the recovery of affected households, decrease household vulnerability and support healthy post-mining communities

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