Silica Exposures in Artisanal Small-Scale Gold Mining in Tanzania and Implications for Tuberculosis Prevention

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Introduction

A major occupational health hazard associated with mining is exposure to respirable crystalline silica dust which is known to cause silicosis, cancer and other disease.(1) Mining in Sub-Saharan Africa is also associated with higher incidence rates of pulmonary TB and these rates are typically 5-6 times higher among miners than in the general population.(2)

Crystalline silica in the form of quartz is the most common component of soil, sand, and rocks. Crystalline silica dust is released into the air when miners drill, transport, and crush ore in the effort to extract and process minerals. While some attention is paid to reducing crystalline silica exposures in some large-scale mines in developing countries, artisanal small-scale gold mining (ASGM) is generally unregulated or illegal and conducted without regards to health and safety considerations. We were unable to locate any published exposure data from small-scale mining operations despite the growth in ASGM over the past decade fueled in part by rising gold prices. (3)

Tanzania is a country with significant mineral resources, including gold. ASGM accounted for an estimated 10% (5 tons) of the country's total gold extraction in 2010.(4) It is estimated that between 500,000 and 1.5 million people in Tanzania work in ASGM operations and are representative of the 15 million artisanal miners around the world. (5)

Silicosis is normally not apparent until 20 years or more after the first exposure to crystalline silica. However with exposure to extremely high concentrations of crystalline silica, an acute or accelerated form of silicosis can occur in 1-3 years. An exposure assessment was conducted in several Western Tanzania villages on July 14-16, 2014, to characterize miners' exposure.

Purpose

The purpose of this project was to measure respirable crystalline silica exposures among workers in ASGM in Tanzania. Because small-scale gold miners lack basic personal protective equipment and generally operate without any dust controls, it is important to assess their exposures separately from workers in medium and large scale mines operated by mining companies. This investigation was also performed to evaluate potential interventions to reduce airborne respirable dust in these operations to better protect workers and surrounding communities.

Method

Air samples were collected in the breathing zone of workers by drawing air through pre-weighed three-stage 37-mm polyvinyl chloride (PVC) filters (5 µm pore size) with battery operated air sampling pumps at a flow rate of 2.5 liters per minute. The filters were downstream from SKC aluminum cyclones (with a 50% aerodynamic diameter cut-point at 4 µm) to collect the respirable portion of the dust.

All personal samples were collected on unique individuals except when two consecutive samples were collected to complete sampling within a single day work shift. In some cases area air samples were collected from stationary worksite locations approximately 1-2 meters above the ground near crushing, hammering, and loading operations. A field blank sample was collected on each day as per method requirements. Air sample durations included a mix of full and partial work days for representative miners. However because of the defined division of labor observed, we considered partial shift sample durations to be representative of full shift exposures. As individual exposures appeared to be generally consistent throughout the workday, we did not calculate time-weighted averages (TWA) for partial shift sampling. TWA calculations would underestimate actual exposures in cases where sampling periods were less than full shift.

Three bulk samples of processed ore were collected from mining or processing sites in different villages to determine the type of crystalline silica present and its concentration. The bulk material and 36 air sample filters (including blank samples) were analyzed by EMSL, Inc. (Cinnaminson, N.J.) with NIOSH Method 7500 using X-ray diffraction. The limit of detection for gravimetric respirable dust with this NIOSH method is 0.05 mg and the limit of detection for silica dust as quartz is 0.005 mg. (6)

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Assessment

Air monitoring for respirable silica was conducted during five artisanal mining and processing operations, including drilling, manual hammering, loading, crushing, and miscellaneous processing operations.

Miners wearing monitoring devices for respirable silica dust

Miners used pneumatic jackleg drills powered by diesel generators at the surface while working in underground mines. The jacklegs are used to loosen ore, which was then gathered in bags and brought to the surface using a manual or powered winch.

Hammering rocks into smaller ones

Mines with powered winch

Crushing ore into finer material

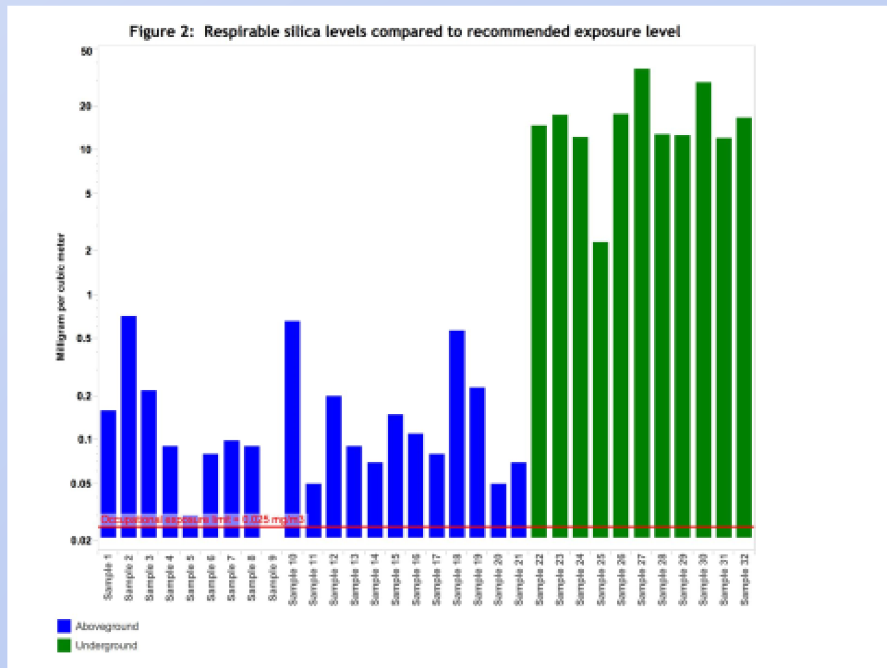
The ore on the surface was transported by laborers to other sites to be manually hammered into smaller sizes and then mechanically ground using ball mills. Many of the mining and milling sites were located near residential dwellings.

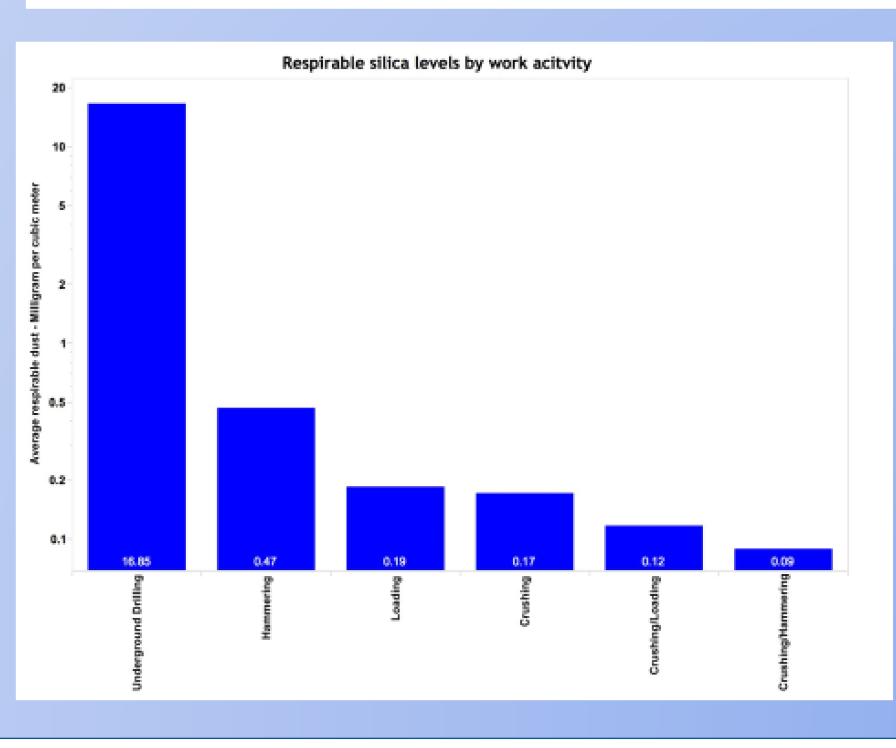
Community Exposure

Loaders

Results

Airborne crystalline silica exposures exceeded recommended limits for all tasks monitored with an average exposure of 16.85 mg/m3 for underground drilling that was 337 fold greater than the recommended exposure limit (REL) published by the U.S. National Institute for Occupational Safety and Health (NIOSH) and 0.19 mg/m3 for above ground operations or 4 fold greater than the REL. Thirty-one (97%) of the 32 air samples (excluding blank samples) exceeded the NIOSH REL. The exposures measured raise concern for possible acute and chronic silicosis and are known to significantly contribute to TB incidence rates in mining communities.





Conclusion

Respirable crystalline silica dust exposures in gold mining are known to greatly increase the morbidity and mortality of workers due to silicosis and other silica related disease. The exposures noted in underground drilling operations will place workers at risk for developing acute silicosis within five years of initial employment unless measures are taken to reduce these exposures. In addition, lower levels of respirable crystalline silica than those reported here are associated with an increased prevalence of TB among miners.

In light of these results, there is an urgent need to introduce dust control measures to help prevent TB in ASGM communities around the world. Ongoing efforts by bilateral and multilateral aid agencies should immediately incorporate dust controls into mercury reduction efforts in ASGM. Such efforts have the potential to do more to reduce morbidity and mortality among miners than the introduction of mercury capture technology and non-mercury alternatives. As most airborne crystalline silica is generated during mining and processing before the application of mercury at the end stage, a combined approach would have the greatest public health impact.

Given the expense and challenges of conducting outreach to encourage the implementation of improved work practices in remote and widely dispersed ASGM sites in many countries, the incremental effort to include crystalline silica dust controls is proportionally small. There are significant public health benefits to an integrated approach to introduce wet methods for reducing respirable crystalline silica dust while demonstrating safer mercury use or alternative technologies.

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