



Human health and safety in artisanal and small-scale mining: an integrated approach to risk mitigation



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ABSTRACT

Artisanal and small-scale mining (ASM) is a critical poverty reduction strategy for millions of people around the world; however, it is notoriously dangerous. While there is an awareness of the dangers associated with ASM activities, with the exception of mercury contamination from artisanal *gold* mining activities, health and safety risks among artisanal miners, their families, and their communities have not been fully addressed in the scholarly literature or by regulatory institutions in countries where ASM is prevalent. This article applies a participatory action framework and draws from three different but complementary data sources, including a survey administered to ASM scholars and practitioners, data gathered from participants in Australian Government-sponsored short courses at the University of Queensland (UQ), and interactions between scholars from UQ and Mongolian mine inspectors, to demonstrate the growing significance of an integrated research approach to understand the full scope of health and safety risks facing the ASM sector. It also reveals some of the practical challenges to mitigating health and safety risks, specifically capacity building among regulatory agencies who work with limited resources to meet the inspection requirements of both the large- and small-scale mining sectors. This article concludes that research on health and safety issues in the ASM sector must incorporate a more holistic and regional approach with both qualitative and quantitative data collection methodologies.

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1. Introduction

Mining is a notoriously dangerous occupation. Where reliable national statistics exist, mining generally ranks in the top three occupations for related diseases and fatal accidents (Vingård and Elgstrand, 2013: 6). In large-scale mining endeavors, the management of health and safety largely relies on governmental regulation of mining companies, institutionally enforced compliance mechanisms, and company policies and procedures. In contrast, health and safety issues in the artisanal and small-scale mining (ASM) sector have not been fully addressed by governments or regulatory institutions, in part because ASM activities often take place in rural areas and frequently operate “extralegally” (Siegel and Veiga, 2009: 52), aligning with local customs and land tenure traditions but

operating outside the bounds of a state's legal frameworks (Vingård and Elgstrand, 2013). As a result, many countries have minimal or no compliance mechanisms and lack well-established reporting systems for artisanal and small-scale miners, and few if any facilities or resources exist to address health and safety problems in the ASM sector. Therefore, the majority of ASM-related accidents, fatalities, and ailments are likely undocumented, and as a result are underrepresented in national and international statistics (Hermanus, 2007; Miserendino et al., 2013). The lack of reliable data and regulatory oversight of ASM activities present obvious obstacles to improving conditions where the health and safety of miners and their communities is at risk (Hentschel et al., 2002).

Because ASM represents a critical poverty reduction strategy for millions of people around the world and government officials recognize the important economic contributions of ASM activities for households and communities, mining policy reforms in the developing world are increasingly aimed at formalizing and regulating the ASM sector. Formalization is often presented as a key strategy for increasing the sustainability of ASM activities, creating

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benefits for communities, and minimizing negative environmental and human impacts (Maconachie and Hilson, 2011; Siegel and Veiga, 2009; Teschner, 2012). Furthermore, training and sensitization programs aimed at improving the health and safety conditions of artisanal and small-scale miners and their communities hinge on appropriate policy interventions as part of formalization efforts (Veiga et al., 2014). The growing importance of health and safety to current policy and development decisions makes it imperative that we achieve a more comprehensive understanding of health and safety issues among artisanal and small-scale miners, their families, and their communities, whether they operate in the formal or informal economy. Identifying and understanding the risks people encounter in their everyday lives and how they understand and attempt to mitigate these risks, is an essential step in addressing risk in a way that contributes to more sustainable rural livelihoods globally.

With the exception of mercury exposure among the artisanal and small-scale gold mining sector, health and safety risks among small-scale miners, their families, and their communities have not been fully addressed in the scholarly literature or by regulatory institutions in countries where ASM is prevalent. Moreover, the barriers that exist to mitigating some of these risks have been undertheorized and simplified leading to practical challenges in developing and implementing health and safety interventions for the ASM sector. In this article, we argue that there is a growing need to understand and address health and safety among the ASM sector using a more holistic and regional approach that incorporates both quantitative and qualitative data collection and analyses. Drawing from three different but complementary data sources, including a survey administered to ASM scholars and practitioners, data gathered from participants in Australian Government-sponsored short courses at the University of Queensland (UQ), and interactions between scholars at the Minerals Industry Safety and Health Centre (MISHC) at UQ and Mongolian mine inspectors, this article demonstrates the significance of an integrated research approach to understanding the full scope of health and safety risks facing the ASM sector. It also reveals some of the practical challenges to mitigating health and safety risks, specifically capacity building among regulatory agencies who work with limited resources to meet the inspection requirements of both the large- and small-scale mining sectors.

This study is grounded in a participatory action research (PAR) framework as it has been applied to rural and community development. Participatory action research is a collaborative and iterative approach aimed at creating change (or practical outcomes) through research (Kindon et al., 2008). This framework employs methods designed to support rural participation through meaningful engagements between the researcher and the community who will benefit from the development intervention (Chevalier and Buckles, 2013: 21; Gonsalves et al., 2005). The research presented here shifts the lens of PAR by situating ASM scholars, practitioners, and regulators as the *community* to help identify the ways in which the existing literature and regulatory environments relate to their research and everyday working environments. Expanding the PAR framework to include the perspectives and experiences of scholars and practitioners represents a step toward designing holistic PAR frameworks that effectively engage the wide range of stakeholder communities integral to some of the most pressing global issues of our time.

2. Artisanal and small-scale mining livelihoods and health and safety risks

Artisanal and small-scale mining is a growing sector that produces up to 20% of global minerals and metals (Buxton, 2013;

Jennings, 2003). While some estimates place the number of people working in ASM at over 13 million worldwide (ILO, 1999), others suggest that the number may be over 50 million (Veiga and Baker, 2004). Furthermore, for each person employed directly in the ASM sector several more are dependent on the activity as part of their livelihoods (Hilson and McQuilken, 2014; ILO, 1999). Over the last decade, the global mineral boom coupled with the continued diversification of rural livelihoods due in part to the effects of climate change (Agrawal, 2010), processes of deagrarianization (Banchirigah and Hilson, 2010), and increasing population pressures (Lahiri-Dutt, 2004) suggests that the number of people who depend on ASM is steadily increasing, and ASM continues to be an important livelihood strategy for rural people worldwide. However, ASM is a livelihood that carries considerable risk.

Livelihoods and risk are closely linked in rural areas of the developing world. Extreme climatic conditions (Agrawal, 2010), natural disasters (Wisner et al., 2004), and market uncertainties (Bryceson, 2002; Bryceson and Jønsson, 2009; Chalfin, 2000) pose threats to rural livelihoods and are often mitigated through mobility or diversification strategies (Barrett et al., 2001). Individuals and households that rely on ASM as part of a livelihood scheme are challenged by these externalities, but they are also prone to the risks associated with mining and mining-related undertakings (i.e., processing ore). A survey of ex-miners in Tanzania revealed that 45% ended their careers in mining because of “unhealthy, hard and risky work” (Bryceson and Jønsson, 2010: 389), and in Ghana, artisanal and small-scale miners identified *galamsey* or small-scale mining (along with taxi driving and operating a chain saw) as the most hazardous livelihood option available to them (Tschakert, 2009: 28).

In spite of the recognized risks, ASM is an integral part of an overall livelihood strategy for many households worldwide, and there is a growing consensus that ASM is mostly poverty driven (Aryee et al., 2003; Hilson and Garforth, 2013; Hilson and Pardie, 2006; Hoadley and Limpitlaw, 2004; Yakovleva, 2007). Other evidence from research on livelihood diversification strategies in rural areas also suggests that mining-related activities may be undertaken opportunistically to fill gaps in the value chain (McCabe et al., 2014; Smith, 2014). Nonetheless, ASM provides many benefits to rural communities; it can be a source of identity and cultural belonging, it provides employment and cash for families, which can help alleviate poverty, and it often results in increased participation in schooling and other business activities (Lole, 2005). Artisanal and small-scale mining activities may also reduce the negative impacts of rural-urban migration (Hinton, 2006).

While ASM has the potential to contribute to more sustainable livelihood strategies, poor working conditions, accidents, and disease can reduce worker productivity and income for dependents, burdening families and communities. Artisanal and small-scale miners are usually engaged in heavy and precarious manual labor and frequently utilize rudimentary or unsafe mining and mineral processing techniques. In addition, the impacts of ASM activities often extend beyond the miners themselves to their families and communities who are exposed to environmental pollution and hazards either through their participation in various parts of the mining commodity chain or because of their residential proximity to mining activities (Maier et al., 2014). Undoubtedly, the single most pressing issue impacting health and safety in the ASM sector is mercury use by artisanal and small-scale gold miners because of its harmful effects on both human health and the environment.

2.1. Mercury

Scholars, policy-makers, and development practitioners are paying close attention to the risks associated with mercury use in

artisanal and small-scale gold mining (ASGM). The impacts of mercury on human health and the environment are well documented (Cordy et al., 2011; Eisler, 2003; Gibb and O'Leary, 2014; Schwarzenbach et al., 2010; Spiegel and Viega, 2010), and ASGM is the largest human source of mercury emissions, contributing around 35% of total anthropogenic emissions globally (UNEP, 2013). Since the early 1990s, the reduction or elimination of mercury in ASGM has been a focal point of several international initiatives. The Global Mercury Project launched in 2002 by the United Nations Industrial Development Organization (UNIDO) was formed to assess the extent of mercury contamination in ASGM areas of the world, remove barriers to the adoption of cleaner technologies, and build capacity for the development of policy, regulatory, and economic mechanisms to minimize mercury pollution (Spiegel and Veiga, 2005; Veiga and Baker, 2004). In concert with this, the United Nations Environment Programme (UNEP) Global Mercury Partnership was formed in 2005 with the goal of protecting human health and the environment from the release of mercury; reducing mercury in ASGM is one of eight priority areas (www.unep.org). As part of its mandate, the Global Mercury Partnership supports stakeholders in ratifying and implementing the Minamata Convention on Mercury, a global treaty enacted in 2013 aimed at controlling the anthropogenic releases of mercury (www.mercuryconvention.org). There is a great deal of momentum toward supporting educational initiatives and implementing programs that promote cleaner processing techniques to reduce the risks of mercury in the ASM sector (Hinton et al., 2003b; Metcalf and Veiga, 2012; Sousa et al., 2010; Spiegel and Veiga, 2005; Veiga and Meech, 1995; Zolnikov, 2012).

2.2. Beyond mercury: health and safety research and ASM

The existing research on health and safety in the ASM sector, outside of the focus on mercury use and its impacts, is dominated by three key themes including: (1) artisanal and small-scale miners are exposed to a great deal of risk; (2) exposure and vulnerability to risk occurs uniquely among different players in the mining commodity chain; and (3) perceptions and beliefs about risk in the ASM sector are socially and culturally specific. A close examination of the literature, however, shows that the coverage of these topics is somewhat limited due to the emphasis placed on *either* quantitative or qualitative data collection methods and analyses to understand ASM-related health and safety risks, perceptions, and mitigation strategies. Following is an overview of the important research on non-mercury related health and safety issues in the ASM sector.

A recent study conducted by Basu et al. (2015) provides an overview of health and safety hazards among the ASM sector in Ghana and advocates for public policy decision-making to be grounded in empirical, scientific data. The authors conduct an integrated assessment to quantitatively document exposures to mercury and other heavy metals, as well as the health risks miners and their communities face from injuries and noise exposure (Basu et al., 2015). They also provide an overview of the existing data on psychosocial health, nutrition, cardiovascular and respiratory health, sexual health, and water and sanitation (Basu et al., 2015). Basu's study highlights the broad range of health and safety issues that impact both miners and their communities and addresses the need for more systematic studies that examine the relationship between the ASM and health outcomes.

Myriam Elenge and her colleagues provide an in-depth look at the accidents and hazards artisanal and small-scale miners are exposed to in the copper and cobalt mines of the Katanga province of the Democratic Republic of Congo (DRC). Elenge et al. (2013) quantitatively demonstrate that over 72% of miners were

impacted by workplace accidents over the course of twelve months. The authors conclude that age, seniority, and the presence or absence of apprenticeship did not produce significant differences in accident outcomes and that improved tools and adequate training can aid in accident prevention (Elenge et al., 2013). In another study from the same region, Elenge and De Brouwer (2011) reveal that exposure to hazards depends on the particular job a person holds in the mining process. Elenge's research is especially useful for illustrating the amount and types of risk miners are exposed to and demonstrating the value of a context specific understanding of ASM activities in a particular region. A more rigorous qualitative investigation of miners and their families would complement Elenge's quantitative analysis by revealing miners' risk perceptions, whether these perceptions influence their behaviors, and to what extent miners attempt to mitigate risk.

Similarly accentuating the value of understanding the local context of health and safety, Anna Marriott's (2008) master's thesis provides an examination of two ASM sites in South Africa and emphasizes the links between health and safety and poverty reduction. In this study, Marriott explores the prevailing health and safety challenges at each mine site, worker's attitudes towards these challenges, and the existing opportunities and constraints for workers to access protections. Finally, Marriott looks at the ways in which "non-conventional" health and safety stakeholders, such as local governments, formal mining companies, traditional authorities, and landowners can play a vital role in health and safety protections for informal miners (2008: 53). Marriott's analysis demonstrates that health and safety mitigation strategies for the informal mining sector will be appropriate and effective only if they are based on research and policy approaches that are embedded in the local context within which miners operate and only when miners are identified as "economic agents" critical to poverty reduction (2008: 143).

Providing further evidence of the context-specific perceptions of risk and risk-related behaviors through a qualitative analysis, Soemarwoto and Ellen (2010) demonstrate how artisanal and small scale gold miners in West Java rely on traditional justifications of misfortune to explain tunnel collapses, yet adopt new ideas about causality and risk management to explain the risks associated with mercury use. This research shows how health and safety risks are interpreted and mitigated in unique ways. Offering another qualitative examination of risk among artisanal and small-scale miners in Suriname, Marieke Heemskerk (2001) concludes that contrary to common stereotypes, artisanal and small-scale miners are well aware of the risks inherent to mining and use various strategies to minimize these risks (Heemskerk, 2001). Similar to Elenge's research in the DRC, Heemskerk provides evidence of the context- and job-specific nature of health and safety risks in ASM. She also underscores the role that macro-level factors such as gender inequality play in risk exposure by highlighting the ways in which men and women are exposed to and impacted differently by health and safety risks depending on their respective roles in the mining commodity chain.

Mining often involves both occupational and community health and safety hazards that not only affect miners, but also their families and communities. Family members are frequently involved with ore processing thereby exposing them to mercury, dust, and other chemicals. Women are especially vulnerable to the health and safety risks associated with mining (Armah et al., 2016; Hinton et al., 2006; Lahiri-Dutt, 2011; Lahiri-Dutt and Macintyre, 2006; Lu, 2012). According to the International Labour Organization (ILO), 3.5–4 million women are engaged in ASM (Lu, 2012), and in some places, women provide up to 50% of the ASM workforce (Vingård and Elgstrand, 2013; Lu, 2012). Women often experience the "double burden" of having both work and home responsibilities

(Lu, 2012: 103) and are frequently found at the bottom of the sector's hierarchy, making them more vulnerable to health and safety risks (Dreschler, 2001). They may also be exposed to health and safety risks because there is often little distinction between activity areas. For example, in some ASM communities, the processing of ore is carried out by women near or within the home space, where women crush ore and assist with refining the ore while taking care of the children (Collins and Lawson, 2014; Hinton et al., 2003a). This can cause harmful exposure among women and children to dust and chemicals used in processing.

Children are another vulnerable population within the ASM sector. It is estimated that about 1 million children work in mining globally (<http://www.ilo.org>). Children are often used in mining operations to help transport, sort, or wash material and because of their size, they may also work in narrow underground tunnels (Elenge et al., 2013). Children of female miners frequently accompany their mothers to mine sites, exposing them to health and safety risks. Migrant laborers are also a vulnerable population, and the impacts of mining activities on this group are virtually unknown, since by the time certain mining-related diseases like pneumoconiosis clinically manifest, many workers have left the area and the mining trade altogether (Vingård and Elgstrand, 2013). Environmental and community pathogens have regional impacts that also impact miners, their families, and their communities. For example, open pits that fill with water during the rainy season may serve as a breeding ground for malaria carrying mosquitoes or other parasites (de Andrade et al., 1995; Confalonieri et al., 2014).

Some studies have shown that there are significant health and safety risks that impact miners and their communities because of the social context in which mining takes place. ASM work often takes place in remote areas where access to health care, schools, basic sanitation, or other social services is minimal at best (Vingård and Elgstrand, 2013). In addition, mining camps are areas where prostitution and drug use are common, exposing miners and communities to increased risks of HIV/AIDs and other sexually transmitted diseases (Ballard and Banks, 2003; Hentschel et al., 2003). Finally, lifestyle factors can compound the impacts of mining. For example, it has been shown that coal miners who smoke cigarettes are at a higher risk of developing lung disease than non-smoking miners due to the compounding effects of cigarette smoke and exposure to dust particles (Hnizdo, 1992; Hnizdo et al., 1990).

The reasons why ASM miners and communities take risks, how they weigh their livelihood options, and what they do to mitigate risks are not very well understood. The influential Global Report on Artisanal and Small-scale Mining produced by the Mining, Minerals, and Sustainable Development Project (MMSD) proposed a number of reasons for increased health and safety risks in the ASM sector. These include: 1) A lack of economic resources; 2) A lack of or non-application of safety regulations; 3) A general unawareness of health and safety risks; 4) Illiteracy; 5) A lack of training; 6) Inadequate equipment; and 6) The remote location in which many ASM activities take place (Hentschel et al., 2002). However, how these barriers to avoiding or mitigating risk intersect with one another and how this plays out in people's daily lives is unclear.

The existing research draws attention to the need for studies that incorporate a more holistic approach that theorizes health and safety risks, risk perceptions, and mitigation strategies as they relate to particular historical, political, economic, and social settings. Furthermore it highlights the necessity for a more regional approach that addresses the risks miners confront in their daily work lives, as well as the risks faced by miners' families and communities due to their involvement in the ASM commodity chain or by virtue of their proximity to ASM activities.

3. Materials and methods

The study reported on here is informed by an array of methods that support the PAR framework. The University of Queensland Sustainable Minerals Institute (SMI) is uniquely situated to apply this framework because of its longstanding success applying PAR frameworks to problem solving in the mining sector. Furthermore, the interdisciplinary make-up of scholars at SMI enables a multi-dimensional perspective that deepens our understandings of the ASM sector. To begin with, researchers at the Centre for Social Responsibility in Mining (CSRSM) at SMI conducted an extensive interdisciplinary review of the scholarly and grey literature on ASM to create a comprehensive list of the health and safety risks that impact miners, their families, and their communities (Table 1).¹ These risks were divided into the following three categories designated by The National Institute for Occupational Safety and Health at the Centers for Disease Control and Prevention (www.cdc.gov/niosh/): (1) diseases and injuries, (2) hazards and exposures; and (3) chemicals. The table was distributed via individual email, along with a five-question survey with both open- and close-ended questions, to a network of eighteen ASM scholars and practitioners who work in various areas of the world. The participants were identified because of their practical work and/or publication record on ASM and ASM related topics; most of them were also part of the research teams' professional networks. Eight of the eighteen initial contacts returned the survey; non-participation was mostly attributed to a lack of time.

The survey asked participants to assess the provided table of health and safety risks and identify any that were missing. They were then asked to list the top three (unranked) health and safety risks they considered to be most serious to artisanal and small-scale miners and then do the same for ASM communities in general. The participants were not provided with suggested themes to populate the list and were expected to draw from their own research and field experiences. The participants were also asked to rank a list populated through the literature review of the eight most pressing challenges in the way of mitigating health and safety risks in the ASM sector. The rank orders given to each list item by the participants were averaged, and a final number was assigned that signals the emphasis put on the item by the participants. One out of the eight participants declined to complete the ranking exercise because of the perception that all of the listed items were concurring and interrelated.

This study also incorporates data collected from thirty-four Work Plans on Return (WPRs) focused on ASM and created by professionals from government, civil society, and academic institutions in eighteen developing countries as part of their participation in short courses at UQ. Short courses were focused on the socioeconomic and environmental aspects of mining and were held from 2012 to 2014.² The WPRs were part of a strategy for integrating the subject matter of the short-course into the participants' professional agendas. The WPRs allowed participants to reflect on their learning and develop a tangible plan of action to implement upon their return to their home countries. Work Plans on Return not only reflect the content of the short-course, but also highlight

¹ The Centre for Social Responsibility in Mining (CSRSM) and the Minerals Industry Safety and Health Centre (MISCH) are two of seven centres housed within the Sustainable Minerals Institute (SMI) at UQ.

² The WPRs were drawn from the following Australian-aid-funded courses, which ran from 2012 to 2014: 2012 Short Course in Managing Corporate Community Relations; 2012 African Women in Mining and Development Study Tour; 2012/2013 Occupational Health, Safety and Environment Short Course; 2012/2013 Community Aspects of Resource Developments (CARD) Short Course; 2014 Environmental Management in Mining.

Table 1
Comprehensive list of risks to artisanal and small-scale miners and their communities.

Diseases and injuries	Hazards and exposures	Chemicals
Ergonomic stresses	Landslides	Mercury (used in gold processing)
Musculoskeletal disorders and diseases (arthritis)	Decompression sickness (from diving)	Cyanide (used in gold processing)
Respiratory diseases	Airborne pollutants (equipment exhaust, dust)	Arsenic (naturally occurring)
Noise and hearing loss	Heat and cold stress	Chromium (naturally occurring)
Parasitic infections (malaria)	Poor air quality/ventilation	Radon (naturally occurring)
Bloodborne infectious diseases (HIV/AIDS, Hepatitis B/C, Ebola)	Blasting/explosives	Aluminum (naturally occurring)
Cancer (occupational)	Rock falls	Copper (naturally occurring)
Neurotoxicity	Flooding	Manganese (naturally occurring)
Airborne infectious diseases (TB)	Stumbling, slipping, and falling	Nickel (mined and naturally occurring)
Dengue fever	Unstable underground Structures	Zinc (used in gold processing)
Diseases of blood and skin	Obsolete, inappropriate or damaged equipment	Lead (emitted during processing and naturally occurring)
Traumatic injury	Poor visibility and light	Cadmium (naturally occurring)
Water/soil/food contamination related diseases (cholera, typhoid)	Poorly built tunnels	Cobalt (mined and naturally occurring)
Enteric (intestinal) infections	Lack of exits	Selenium (naturally occurring)
Lifestyle factors (smoking related diseases, inadequate nutrition, alcohol and drugs, STDs, HIV/AIDS)	Gender-based violence and abuse	Uranium (mined)
Genital corrosions and miscarriages (from prolonged standing in water)	Dense living arrangements	Methane (naturally occurring)
Skeletal fractures	Remoteness of work	
Cardiovascular diseases	Poor sanitation	
Mental impairments; psychological effects	Water, soil, and food contamination	
	Vampire bat attacks ^a	
	Improper use of chemicals	
	Social conflicts	

^a As a result of the clearing out of wild vertebrate hosts and the replacement of these populations with human hosts; also facilitated by the “precarious” shelters miners may inhabit (Confalonieri et al., 2014).

some of the key issues professionals involved with mining development encounter in their countries. The countries represented by the WPRs include Burundi, Cameroon, Central African Republic, Ethiopia, Ghana, Kenya, Liberia, Madagascar, Malawi, Mozambique, Nigeria, Peru, Philippines, Rwanda, Senegal, Sierra Leone, Tanzania and Zambia. The majority of professionals (23 participants or 68%) represented mining ministries in the various countries, followed by universities or technical institutions (5 participants or 14%), other government departments (4 participants or 12%), and civil society organizations (2 participants or 6%). This portion of the analysis was conducted as part of a project funded by the International Mining for Development Centre (IM4DC)³ aimed at investigating strategies employed around the world to deal with the many and varied issues associated with ASM (Collins and Lawson, 2014).

The final methods applied in this study to understand the importance of having relevant frameworks to address health and safety among the ASM sector include participant observation and iterative feedback sessions with the Mongolian Mining Inspectorate. As part of a wider project, also funded by the IM4DC, researchers from the Minerals Industry Safety and Health Centre (MISHC) at UQ conducted three visits to Mongolia in May 2012 (5 days), October 2012 (13 days), and May 2013 (15 days) to collaborate with Mongolian mining inspectors to address the training needs of the Inspectorate. During these trips, the MISHC researchers and the Mongolian mining inspectors traveled to two mining areas, a coal-mining district in Nalaihk (May 2012) located approximately 40 km southeast of Ulaanbaatar and five legal small-scale alluvial gold mining operations located in the Zaamar District (May 2013) located in the Tuul valley approximately 180 km west of

Ulaanbaatar. Both areas had formal and informal operations, and the interactions of the inspectors were observed, as well as the social and environmental context in which their work took place. The issues identified during the visits were discussed during subsequent workshops in Ulaanbaatar. The initial workshop in May 2012 involved thirty-two inspectors who are involved in inspection and compliance processes from the General Agency for Specialised Inspection (GASI) from both Mining and OHS Labor Inspectorates, including those who were part of the coal site visits. The second workshop in May 2013 involved thirteen inspectors from the Mining Inspectorate. These workshops were organized according to the PAR framework with GASI assisting in the continued development and implementation of improved control mechanisms for both formal and informal mining operations.

4. Results: evidence for an expanded health and safety focus

The results presented in this section are drawn from three distinct but complementary data sets. A discussion follows that examines the relevance of the data to the growing need for more research on and detailed analyses of health and safety issues in the ASM sector.

4.1. ASM expert survey

Five out of the eight surveys (63%) completed by the ASM scholars and practitioners cited mercury exposure in the top three health and safety risks to miners (Table 2). Four out of eight respondents (50%) named rock falls and pit collapses, and four out of eight (50%) cited risks associated with working underground in poorly ventilated spaces including exposure to dust and respiratory disease. Two of the respondents (25%) identified environmental and community pathogens such as parasites, HIV/AIDS, and tuberculosis (TB) in the top three risks to miners. Finally, a range of

³ The IM4DC was created in 2011 and works in partnership with the Australian Government, the University of Western Australia, and the University of Queensland to support the sustainable use of mineral and energy resources in developing nations.

Table 2
Top three health and safety risks to miners, as identified by ASM scholars and practitioners.

Health and safety risks	Number of respondents who listed	Percent
Mercury	5	63%
Rock falls and pit collapses	4	50%
Ventilation and respiratory diseases/dust	4	50%
Environment and community pathogens: parasitic, bloodborne (AIDS), TB	2	25%
Ergonomic stresses	1	13%
Lifestyle factors	1	13%
Noise	1	13%
Limited exits	1	13%
Traumatic injuries	1	13%
Lack of safety culture, training and personal protective equipment	1	13%
Temporary living conditions (crowded, unsanitary, conflict, no services)	1	13%
Conflicts	1	13%

risks were identified by one respondent each (13%) including ergonomic stresses, unspecified lifestyle factors, noise, limited exits in underground tunnels, traumatic injuries, a lack of safety culture, training, and personal protective equipment, the negative impacts of temporary living arrangements including crowded living spaces, unsanitary conditions, and a lack of services, and finally, social conflicts among miners and between miners and surrounding communities, mining companies, and authorities.

With regard to the risks faced by ASM communities in general, mercury use continued to be cited as a significant risk with four out of the eight (50%) respondents including mercury in their top three listed items (Table 3). However for this group, the related risk of water contamination appeared more often, with five out of the eight respondents (63%) listing it in their top three identified risks. Other identified risks to ASM communities listed by three of the respondents (38%) included infectious diseases such as HIV/AIDS and other sexually transmitted diseases. Cyanide exposure was listed by two respondents (25%) along with the use of child labor. Finally, gender or domestic violence, landslides, abandoned mines, unspecified lifestyle factors, and conflicts between local communities and migrant populations were all listed by one respondent each (13%).

In the ranking exercise, the lack of attention given to ASM in policy and regulatory frameworks surfaced as the primary challenge to mitigating health and safety risks among the sector, followed by the closely related challenge that illegal ASM activities make it difficult or irrelevant to enforce health and safety regulations (Table 4). These were followed by the challenges associated with the general lack of support and training for the ASM sector, as well as those linked to the tradeoffs miners and communities make between health and safety and livelihoods. The next ranked items included the problems of inadequately trained inspectors to enforce compliance, the lack of miners' access to or cash for materials and equipment, and inadequate knowledge or awareness of risks among workers and their communities in the ASM sector. The last identified

challenge was miners' and ASM communities' resistance to government or non-governmental (NGO) interventions.

4.2. WPRs

Twelve of the thirty-four WPRs (35%) reviewed for this study were primarily about health and safety among the ASM sector, with an additional four WPRs containing significant health and safety aspects. There was significant crossover in themes, with many of the health and safety focused WPRs also dealing with what could be considered environmental issues. All of the health and safety focused WPRs had a capacity building focus, with eight aimed at delivering sensitization or awareness training to artisanal and small-scale miners and four focused on developing guidelines, manuals, or checklists. Seven of the twelve health and safety focused WPRs (58%) looked to develop informational materials as part of their project. Only two of the twelve WPRs (17%) focused on the use of mercury, one on mercury-free production, and the other on developing good practice guidelines to incorporate into a broader workplace health and safety management system.

Five WPRs (42%) had a focus on the risks and hazards associated with ASM: one aimed to train small-scale miners in health and safety with an emphasis on Job Hazard Analysis to reduce injuries and fatalities (Malawi); one incorporated risk analysis into its mercury awareness raising program (Tanzania); one incorporated risk assessment into its broader health and safety training (Rwanda); and two aimed to raise awareness of miners of the health and safety hazards associated with their activities, including the proper handling, storage, and disposal of chemicals (Nigeria and Sierra Leone). The majority of the WPRs focused on changing the practices of the miners themselves, with only two WPRs dedicated specifically to improving the work of inspectors, and one committed to amending legislation to include comprehensive health and safety guidelines into environmental assessment legislation. One WPR focused on promoting the use of personal

Table 3
Top three health and safety risks to ASM families and communities, as identified by ASM scholars and practitioners.

Health and safety risks	Number of respondents who listed	Percent
Water contamination	5	63%
Mercury	4	50%
Infectious diseases (HIV/AIDS, STDs)	3	38%
Cyanide exposure	2	25%
Child labor	2	25%
Gender or domestic violence	1	13%
Landslides – exacerbated by mining and weather	1	13%
Abandoned mines – fall hazards people and livestock	1	13%
Lifestyle factors	1	13%
Conflict between local communities and migrants	1	13%

Table 4

Artisanal and small-scale mining scholar and practitioner ranked challenges in mitigating health and safety risks among the ASM sector and the average ranked importance given to each item. "R1" stands for respondent no. 1, R2 for respondent no. 2 and so on.

Challenge	R1	R2	R3	R4	R5	R6	R7	AVG
Policy/regulatory frameworks neglect ASM	1	1	1	5	3	1	5	2
Illegal ASM makes it difficult or irrelevant to enforce health and safety	2	6	2	1	2	2	n/a	3
Lack of support/training for ASM sector	3	3	5	7	6	6	1	4
Perceived tradeoffs between health and safety and making a living	5	2	3	3	5	5	n/a	4
Inadequately trained inspectors to enforce compliance	8	7	6	8	1	4	4	5
Lack of access to or cash for materials and equipment	6	4	4	4	7	7	n/a	5
Inadequate knowledge or awareness of risks	4	5	7	6	8	3	2	5
Resistance to outside intervention from government or NGOs	7	8	8	2	4	8	3	6

protective equipment among miners using graphical/pictorial information. This was one of the few WPRs that recognized the importance of alternative methods of communication in working with artisanal and small-scale miners. Only three of the health and safety focused WPRs incorporated data collection on the ground to better understand the reasons for limited uptake of health and safety strategies in ASM, with the majority assuming that a lack of knowledge or awareness of the hazards was the key problem to be solved. However, when pressed further, the professionals held mixed opinions as to the awareness levels of miners in terms of health and safety issues. Some suggested that enduring traditional practices were the key barrier to miners taking safety precautions, rather than a lack of information and resources. Despite this, only one WPR explicitly acknowledged the importance of workplace culture in changing practices.

In follow-up interviews, the majority of the professionals who developed the WPRs stated that they had faced challenges in implementing their projects. One respondent acknowledged the difficulty of implementing initiatives in health and safety for ASM without the corresponding data; small-scale miners do not typically record injuries and deaths, unlike their large-scale counterparts who are required by law to produce such reports.

4.3. The Mongolian example

The limited understanding of potential risks and the consequences of risk-taking behavior coupled with the need for sustainable livelihood activities are evident when considering two mining areas in Mongolia. Given the rapid expansion of the mining industry in Mongolia, it is necessary for the inspectorate to be able to prioritize the inspection and auditing requirements based on the risk profile of the industry, the mining companies and mine sites, and the inspectorate resources available. This results in a focus on legal mining operations.

The Nalaikh coal mining area has both surface and underground operations. There are approximately twenty-nine small mines owned by local operators that have been approved by the Mineral Resource Authority of Mongolia of which three legal mines were visited. In addition, many illegal mines have sprung up where miners work in abandoned mines or dig new mines to extract coal either for personal use or to generate household income. Both types of mines typically only produce a few tonnes of coal per day, and the equipment used is basic.⁴ A small fan blowing air into the mine via collapsible ducting often provides ventilation, and the local Mines Rescue Service (MRS) estimates that about 15–20 small-scale miners die each year in roof collapses or are overcome by irrespirable atmospheres. There is no official inspection system for the

illegal coal mines; however, the small-scale miners are not completely ignored by the MRS who have developed special training equipment such as a maze of small tunnels on the surface to practice rescuing miners from the approved small mines. While the risks associated with the underground, illegal, small mines are recognized, they are generally only addressed when a disaster occurs.

In Zaamar, the alluvial gold mining area in the Tuul valley, the inspection system for the formal small mines is planned in advance for the 12-month inspection regime, and specific aspects are included in each inspection. While the inspections are meant to be risk-based in terms of the issues addressed, the narrow focus of each inspection fails to identify and address other risks or make note of when something is amiss in other aspects. For example, during the visits, the focus of the inspectors was on ground control, slope stability, and rehabilitation. During the visit there were obvious problems with traffic and equipment management at one site, but this was not included in the inspections process or in the report. This focus on a particular issue or issues at legal sites rather than a broader focus on safety and health risks is one of the reasons why illegal mining operations in this area are not included in the inspection system, and illegal miners, even when present on formal sites, and potentially at risk, are ignored during the inspections. During a visit to one legal gold mining operation, illegal miners were observed operating under a potentially dangerous overhang, and no interaction between the inspectors and the illegal miners occurred. The limited focus by the inspectorate demonstrates the lack of an integrated approach to identifying and managing the health and safety risks for ASM irrespective of whether they are legal or illegal operations.

As part of the training needs assessment conducted by MISHC, the Mongolian Mining Inspectorate acknowledged the need to provide assistance to the small-scale mining sector to manage health and safety risks. The General Agency for Specific Inspections (GASI), who represents the Mongolian mines inspectorate recognizes the important contribution that the small-scale mines make to the economy (even when they operate illegally) and to the livelihoods of the local miners and has a genuine desire to maintain safety in the mines. Materials currently available internationally for use by small-scale mining operations were identified; however, there was also a recognized need for: (1) clear guidance materials to assist small miners in managing health and safety; (2) the development of templates for a small-scale mine Safety Management System; (3) formal identification of the inspection requirements for small-scale mines; and (4) the development of assessment tools to allow efficient inspection processes. It was also recognized that further assistance to the small-scale sector is limited by the availability of human and physical resources. Assistance to the illegal sector suffers from the additional issues of the itinerant nature of the industry and the complicating factor that the Inspectorate does not want to be seen to support an illegal activity. In this case, there is a perceived need for formalization or

⁴ Mines supplying the Mongolian Government were receiving approximately \$25 per tonne at that time.

legalization first, and then health and safety issues can be addressed. Yet this perception raises the question of whether health and safety mitigation interventions could instead serve as a pathway to formalization. Is it possible that policy and development interventions aimed at improving health and safety in the ASM sector could serve as incentives for illegal, small-scale miners to formalize?

5. Discussion: salient themes and areas for further research

The three data sets reported on here demonstrate the need for more comprehensive studies that integrate various methods of data collection and analyses to examine the health and safety risks facing the ASM sector, as well as the risk perceptions and mitigation strategies of the various actors working and living in the ASM space. The data from the ASM scholar and practitioner survey shows the broad range of health and safety risks that are associated with ASM. The pointed concerns about mercury use and exposure map onto discussions in the literature and in global policy and regulatory arenas. The survey data also reveal significant concerns about the risks of water contamination to ASM communities. Although mercury contaminates drinking water sources and aquatic food supplies (e.g. fish), mining practices can also impact water sources by creating excess silt and sediment build up and creating conditions where water-borne disease can thrive.

The risks of accidents and exposure to hazards associated with working underground or in poorly ventilated spaces are faced by all underground miners whether artisanal or large-scale, although these risks are better controlled in large-scale mining. This is an area of ASM where the scope of the issue and the impacts are difficult to quantify, and qualitative data on these types of accidents are lacking. For example, it is not clear to what extent family members are impacted by a miner's disability or death. Injured or sick miners who can no longer work can be a "burden" to the community as someone who has to be cared for and provided for. Additionally, another member of the family (such as a child) may have to step into the role that the injured or sick worker is no longer able to fill. The survey data also shows that there are significant risks to miners and their communities that evolve from the social context in which ASM activities take place. Survey respondents addressed a wide variety of these in their responses including gender or domestic violence, child labor, infectious diseases, and conflict. This reinforces the notion that macro-level factors such as poverty and gender inequality are vital to understanding how risk in ASM plays out. These impacts of mining activities and how they differentially impact women, children, and migrant populations are areas of research that certainly deserve more attention.

Perhaps the most noteworthy survey results are the ranked challenges to improving health and safety in the ASM sector. Complementing the MMSD report, the survey results indicate a general view that regulation can lead to better health and safety outcomes and demonstrates the critical role of capacity building among regulatory institutions. Finally, the third most important challenge to mitigating risk identified through the survey is the need for miners to make a living regardless of the risks. This supports the growing consensus that ASM is largely poverty driven and provides an important income source for rural populations who have few other livelihood alternatives.

The health and safety focused WPRs show that knowledge building and sensitization were seen to be of primary importance in tackling health and safety issues in the ASM sector. The fact that only a quarter of the WPRs incorporated data collection on the ground to better understand the reasons for limited uptake of health and safety strategies in ASM coupled with the assumption

that a lack of knowledge or awareness of the hazards was the key problem to be solved, points to a more systematic issue around the lack of data and research into health and safety in ASM. The results of our ASM scholar and practitioner survey, however, suggest otherwise, with participants ranking a lack of information and knowledge about health and safety risks within the ASM sector relatively low on the list of challenges to mitigating health and safety risks in the ASM sector. This implies the perception that miners and their communities may in fact be aware of the risks, but that this awareness may be undermined by other considerations including a lack of training and support to the ASM sector, and the need to make a living, even in a precarious environment. Further baseline data on health and safety risk perceptions can allow for the incorporation of local knowledge and preferences into research agendas and development programs aimed at mitigating some of these risks.

Beyond pinpointing health and safety issues (other than mercury) as a key concern of stakeholders involved in implementing initiatives in the ASM sector, the WPRs showed that training and capacity building in health and safety are still lacking. Along with the follow-up interviews, data from the WPRs also demonstrated the need to identify the full suite of historical and social circumstances that influence health and safety related perceptions and behaviors. It is clear that there is a need for more regionally focused research that expands understandings of health and safety in ASM by quantitatively identifying risks and qualitatively assessing how various players in the ASM commodity chain are exposed to, understand, and mitigate these risks.

The work in Mongolia provides a somewhat more developed approach to mitigating health and safety issues in the ASM sector by focusing on clarifying the role of the inspectorate and improving the skills needed to adequately address and provide guidance to the ASM sector. The large-scale mining sector is generally well served by inspection services that complement and support the safety systems implemented by large mines. This is generally not the situation for the ASM sector. This means that the ASM sector, whether legal or informal, lacks access to training or resources that can help manage the risks associated with their work. Furthermore, it is indicated through their reluctance to support an illegal activity that there is a relative lack of engagement of the inspectors with the ASM sector. An inspectorate that recognizes and understands the nuances of the ASM sector and is skilled in providing advice and guidance has the potential to significantly improve the health and safety of the sector.

6. Conclusions

Research on the health and safety implications of the ASM sector has been dominated by work on mercury-free gold mining technologies. However, there are far broader public health and occupational safety issues that deserve attention. We have argued for a more integrated approach to risk management in this sector which has for too long been reviled by its opponents and romanticized by its proponents. ASM needs to be considered as a high-risk occupation that many individuals undertake out of livelihood necessity as part of a hybrid employment strategy. The sector spans a vast array of minerals from gemstones to gravel and must be recognized in its diversity of health and safety challenges. As development donors reengage with the sector as a development mechanism, the integrated approach we have advocated for in this article could have greater success in mitigating adverse health and safety impacts.

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