A Review of Health Issues Related to Child Labor and Violence Within Artisanal and Small-Scale Mining

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Abstract This review examines health issues around human/social determinants of health within artisanal and small-scale mining (ASM). The focus is on working children and violence. Within the area of violence, the collection of health risks is broad, ranging from self-directed impacts such as suicide or neglect, to interpersonal impacts such as child or intimate partner abuse, and to collective violence such as trafficking, fighting for resources and ultimately war. Discussions on such impacts are less about accidents and illnesses and more about psychological issues. We review studies shedding light on health implications of ASM for children at sites in Suriname and Democratic Republic of Congo (DRC). These studies helped to dispel the perception that the long list of hazards and health risks commonly cited are present at every mining site. Although worker and community interviews provide useful information about accidents and other common ailments, they cannot replace formal medical screenings for serious health problems. There are likely health effects related to criminality and violence. Detailed interviews from Domaine Marial, DRC, with respect to violence to children and intimate women partners are sobering. Violence has also developed with takeovers by local gangs, domestic and transnational organized criminal groups, and insurgent and terrorist groups. Human health can be negatively impacted by worsened working conditions, collateral damage due to fighting among criminal groups and violence more generally, loss of employment or displacement. The negative impacts of ASM can be reduced through policy interventions based on an understanding of what is happening in various countries.

Plain Language Summary Artisanal and small-scale mining (ASM) has been an ongoing enterprise for millennia. With nothing more than primitive tools, gangs of miners work easily accessible deposits of gold, precious stones, colored stones, coal, and more. Modern narratives commonly disparage the worth of ASM, an enterprise that particularly benefits the poorest people in poor countries. Discussions of health issues around children working in ASM are overgeneralized because of a dearth in actual data, and difficulties in understanding poverty issues within the scope of western sensibilities. Health wise, impacts depend on what is being mined, how it is mined and how children participate. Violence and criminality add significant health risks within ASM. Using what limited information is available, the study identifies a collection of physical and psychological risks within mining communities. Again, context is important because of the complexity associated with health determinants. The risks of chemical poisoning and social concerns around mining towns are important within ASM. Criminality and violence are not unexpected in relation to immensely valuable commodities and strategic metals, located in poor but resource rich countries. Traditional ASM is increasingly at risk for collateral health impacts, associated with displacement of indigenous people or control by hostile actors.

1. Introduction

Around the world, several tens of millions of people work in artisanal and small-scale mining (ASM). Traditional ASM involves using primitive tools such as picks, shovels, gold pans, etc. to mine accessible metals, precious stones, colored stones, and industrial commodities such as sand, coal and more (Schwartz et al., 2020). Worldwide, such mining has gone on for centuries or even millennia. Compared to modern industrial mining, ASM is inefficient and labor intensive. A single miner can only process a small quantity of material, limiting the capacity for resource recovery. However, because thousands or tens of thousands of people work a single deposit, the production of gold, diamonds or cobalt can comprise a significant fraction of a country’s total production.
Artisanal mining is usually a legal activity. As the scale and intensity of mining increases through mechanization (pressure jets, backhoes, and dredges), and use of teams of workers in small-scale mining operations, there is an increasing risk that this kind of mining is illegal. Illegal behaviors might include breaking of environmental laws, working in restricted areas, displacement, and smuggling large quantities of valuable commodities, and funding of criminal enterprises. Other criminality can include extortion by intimidation or violence to gain mining areas and to expand claims, or problems such as unfair market practices, illegal taxation, or government corruption (Sovacool, 2019).

The general perception is that ASM comes with many health risks. These are understood in general terms (Stewart, 2020; WHO, 2016) but not in specific detail. This lack of visibility is part of the data problem around ASM, exemplified in part by recycling of old information (World Bank, 2019). Studies of health are especially difficult because mining sites are often located in poorly accessible sites, chronically underserviced in terms of health facilities, and because of security problems related to control by criminal and violent actors (Schwartz et al., 2020).

The list of potential health problems in ASM is long and comprehensive, and includes occupational, environmental, and human/social determinants (Stewart, 2020). Occupational determinants include exposure to hazardous chemicals, dust, the grueling nature of the work, and lack of safety training and equipment (Stewart, 2020; WHO, 2016). There are risks of accidents from improperly constructed excavations and mines, and of death from suffocation, asphyxiation, or drowning. Environmental determinants also create risks, such as mosquito-borne illnesses related to unintended ponding of water in placer mining (Yelpaala & Ali, 2005) or diarrheal diseases due to poor sanitation (WHO, 2016). What is surprising is how common diseases are in terms of health emergencies at artisanal sites (Schwartz et al., 2020). Moreover, problems can end up magnified by combination of remote locations and an absence of medical services, which typically preclude timely treatments (Peters et al., 2008).

Human/social determinants of health are poorly studied as well. These include lifestyle risks, leading to problems like sexually transmitted infections, comorbidities around silicosis, HIV, and tuberculosis, and risks around poverty (Stewart, 2020; WHO, 2016). The category also includes topics around children working and violence, which are the focus of our paper. The dominant narrative is that of developed countries, namely that the participation of children in the mining effort is a worst form of child labor and an activity worth eliminating (ILO, 2005). The arguments are commonly based upon health risks related to the incomplete physiological development of children and susceptibility to accidents given their lack of experience and judgment (ILO, 2011). More pragmatic arguments, discussed in Section 3, support a case for children working given that the hard work they do is comparable to traditional work, for example agriculture in sub-Saharan Africa (Hilson, 2010). Such paying work, while at odds with Euro-American sensibilities, may be preferable to much worse alternatives (Powell, 2014a).

This review also examines health issues around violence and criminality. The collection of health risks is broad, ranging from self-directed impacts such as suicide or neglect, to interpersonal impacts like child or intimate partner abuse, and to collective violence like trafficking, fighting for resources and ultimately war (Krug et al., 2002). Not surprisingly, discussions on such impacts are less about accidents and illnesses and more about psychological issues.

### 2. People and Artisanal Mining—Opportunities and Threats

The study of health risks requires a contextual understanding of ASM, its people, opportunities, and threats. What has become clear is the role of agricultural poverty in driving the growth of artisanal mining (Hilson & Garforth, 2012). Since the 1990s, a decline in agriculture and small farms across sub-Saharan Africa, such as in Ghana, has forced farmers to diversify their incomes into nonfarm activities (Hirons, 2014), including ASM (Hilson & Garforth, 2012). In some places, the ASM workforce includes those with farming backgrounds (Hirons, 2014).

The development of this “poverty narrative” around agriculture countered a prevailing view of miners moving to ASM to “get rich quick” (Hilson & Garforth, 2012; Hirons, 2014). This reality is important for informing resource development policies and better targeting funds around poverty alleviation. This narrative also
identified ASM as an activity with the potential to reduce poverty, which humanizes the face of poverty in Africa (Sovacool, 2019). For example, ASM for cobalt extraction in the Democratic Republic of Congo (DRC) has provided a lifeline for poor refugees and migrants (Sovacool, 2019). In Tanzania, gold mining provided economic benefits, but upward mobility was constrained by lack of experience, industrial knowledge, and capital (Fisher et al., 2009).

Setbacks to poor populations can come in different ways. In eastern DRC, issues around war pushed people out of agriculture (World Bank, 2015). People perceived a “risk of looting and sexual violence from militarized arm groups” (World Bank, 2015). Others experienced difficulties in marketing their produce. ASM fortunately provided a way to earn money. After the war, farming remained problematic, and so mining towns became home to vulnerable populations.

The economic benefits of ASM are counterbalanced by a collection of serious challenges. For example, Sovacool (2019) questioned whether mining in eastern DRC was a net benefit given “accidents and occupational hazards, environmental pollution and degraded community health, exploitation of miners and unfair market practices, the erosion of democracy via corruption and malfeasance, displacement of indigenous peoples, and violent conflict and death.” Scholars working in resources policy acknowledge these problems, but thought that benefits trumped the challenges. For example, Hiron (2014) explained how governments have been unable to properly regulate or to formalize ASM. He argued further that ASM is an area of concern neglected by governments, “development practitioners” and scholars. Another problem is the inability of governments to manage or organize ASM given an absence of basic information (Hilson & Maponga, 2004).

3. Children in Artisanal Mining

Children are involved with artisanal mining. The youngest children simply accompany their mothers to work, older ones look after younger siblings and eventually participate in mining. However, the broader perception in developed countries is that child labor is a practice to be condemned, a worst form of child labor and an activity worth eliminating (ILO, 2005). Major companies now scrub their supply chains to assuage customer concerns, and government agencies, track and report goods and countries involved with child labor and forced labor (USDOL, 2018).

Hilson (2010) argued that this child labor narrative for ASM had been promoted without a real understanding of the extent of problems and the rigors of rural life in sub-Saharan Africa. He advocated a more complexed, nuanced, and pragmatic view. The increasing visibility of children in ASM was related to the decline in agricultural sectors with the concomitant diversification of some farm families into ASM. He argued that “farm work” was a traditional part of childhood in sub-Saharan Africa and culturally appropriate with many mining-related tasks for children similar to agricultural work (Hilson, 2010). Moreover, the money that children received helped to fund their education.

Other research touched on the projection of western sensibilities to developing countries from a different perspective. For example, the idea that adolescent children 12–18 years of age need special protection from onerous labor conditions is less than 150 years old (Fass, 2003). In America, these ideas emerged with some difficulty because many immigrants to America did not share this vision (Fass, 2003). For developing countries, western sensitivities were socially expensive, not well accepted socially, and appeared to require schooling to make them happen (Fass, 2003). Powell (2014a) had a simpler message, namely “the process of economic development has been the greatest poverty cure in human history.” ASM is an important economic driver for poverty reduction in sub-Saharan Africa and elsewhere.

Understanding these issues is relevant to the health because without data, it is easy to propagate an over-simplistic narrative and impractical solutions. For cobalt mining in DRC, Sovacool (2019) framed the issue as “someone stands to lose if cobalt mining patterns move in any direction.” More ASM mining will involve more associated health risks, and less mining will further exacerbate problems of poverty.

Some scholars advocate against blanket child labor prohibitions. With sweatshops in clothing industries, Powell (2014a) argued that children work there because it was the best option available to them and their families. Simplistic prohibitions on child labor can either have little or no impact because children move to
comparable and less visible work, or it can push them into even less desirable work like begging or prostitution (Powell, 2014b). Yet, while acknowledging the undesirability of child labor, he pointed out that children do not work in rich countries “precisely because they are wealthy” and that when countries prosper, child labor goes away.

Another issue is concerns about the validity of assumptions around health upon which broad policies are constructed. The reality is that the health risks come with large uncertainties with respect to prevalence. That uncertainty occurs because ASM is substantially different depending upon what is being mined, how it is being mined, and socio-economic settings.

3.1. Description of the Workforce

Understanding issues of children’s health is limited by the absence of data, starting with respect to the numbers of children involved and in what countries they work (O’Driscoll, 2017). Although limited to gold mining, the numbers of children has been estimated to be > 1 million (Schipper et al., 2015). This number is likely higher given the continued growth in gold mining and the decline in nonindustrial agriculture in Africa and Asia. Simply assuming that a modest fraction of the total workforce in ASM is children under 18 years of age (e.g., 10% of 40 million), yields a significantly larger number.

There are sufficient data available for gold ASM to describe the scope of involvement of children from geographic and economic perspectives. World surveys of 148 goods produced with child or forced labor found agriculture dominating (50%), followed by manufacturing (28%) and mining/quarrying (21%) (USDOL, 2018). Of all goods listed (USDOL, 2018), gold was the most prevalent geographically, mined with the help of children in 21 countries. Brick making with some associated ASM activities was the second ranked employer of children in 19 countries (USDOL, 2018).

With specific reference to jewelry (USDOL, 2018), both in the mining of metals and stones, and in other jobs along the supply chain, children participate worldwide (Figure 1). In total, 29 countries were listed as using children in mining (USDOL, 2018). Efforts were spread widely across the Southern Hemisphere, including low-income countries in Africa and parts of Asia and middle-income countries of South America (Figure 1).

To provide more specific associations with poverty, we match data on multidimensional poverty from surveys (2007–2018) of 101 low- and middle-income countries (UNDP, 2019) with countries using child labor in jewelry production. On Figure 2, the intensity of deprivation (y-axis) is plotted versus the percentage of each country’s population (x-axis) with an intensity of deprivation score equal or greater than 33% (i.e., headcount). The intensity of deprivation is a country-specific average index of poverty determined against 10 factors in areas of health, education, and standard of living (UNDP, 2019).

African countries associated with children working in gold and diamond production self-identify as having the greatest percentage of people living under the worst conditions of poverty (i.e., intensity). Clearly, there is a strong link between children working in sub-Saharan Africa and poverty. Apart from Ghana, >50% of the people in each of these sub-Saharan countries experience relatively intense poverty with a deprivation intensity approximately greater than 45%. The shaded countries on Figure 2 are six of the top seven poorest countries on the list of 101 countries (UNDP, 2019). In addition, the intensity of deprivation is correlated with the relative proportion of a nation’s population in multidimensional poverty. In other words, as the poor become an increasingly larger proportion of a country’s population, there is more intense deprivation due to poverty.

The more prosperous countries at the other end of the spectrum, mostly in South America (Figure 2), are enigmatic. Less than ~10% of their populations are in multidimensional poverty with deprivation intensities of ~40%. However, poverty numbers can have large subnational variability. For example, people in cities are commonly more affluent than those in rural areas (UNDP, 2019). Regional poverty data for Uganda (UNDP, 2019) are particularly illustrative. The present population is ~43 million with ~1.7 million living in the capital city Kampala. Nationally, 56.1% of the country’s population lived in multidimensional poverty, varying from a low of 6% for Kampala to 96.3% for Karamoja, a mining area in northeastern Uganda. The rough terrain, unreliable rainfall, and the legacy effects of prior environmental issues contributes to
unreliable agriculture, food insecurity, and chronic poverty among the ~1.2 million residents (Burnett & Evans, 2014). ASM for gold and marble in Karamoja involved ~18,000 men, women, and children (Burnett & Evans, 2014). This number compared to 50,000 artisanal gold miners countrywide, with 20%–30% of them children (Schipper et al., 2016). Other places with poverty distributed locally include countries in South America. For example, interior regions of Suriname, Colombia, and Peru (Figure 2) are commonly undeveloped and sparsely populated with poor peoples. These include indigenous peoples who in some cases have mined gold for generations (de Theije & Salman, 2018; Masse & McDermott, 2017).

3.2. Potential Health Risks

The health of children (persons under 18 years of age) has been of particular concern. Many organizations, such as the International Labor Office (ILO), view child labor in ASM as a worst form of child labor (WFCL) and an activity worth eliminating. The general health case against the work of children is that impacts affect children more seriously. Because children are actively growing physically and mentally, they are more susceptible to injuries, and lack the judgment and experience to avoid hazards (ILO, 2011). Another consideration is that health problems acquired at an early age, such as neural problems from exposure to mercury or chronic physical disabilities from accidents, represent a continuing economic cost to society (ILO, 2011). Table 1 summarizes the universe of potential hazards and associated health risks. The list is long and similar
Table 1

| Determinants of health | Hazard and specific examples | Associated health impacts |
|------------------------|-----------------------------|--------------------------|
| Occupational           | (i) Chemical exposures      | Neurological damage, genitourinary problems |
|                        | Lead, mercury, other heavy metals from ore crushing, amalgamation | Neurological damage, genitourinary problems |
|                        | Poisonous gases             | Nausea, death            |
|                        | (ii) Dust inhalation        | Silicosis and related respiratory diseases |
|                        | Tunneling, crushing ore     | Silicosis and related respiratory diseases |
|                        | (iii) Accidents, heavy lifting, lagging, tunneling, and picking ore | Silicosis and related respiratory diseases |
|                        | Cave-ins, falling, falling objects | Death, traumatic injuries, head injuries |
|                        | Underwater mining activities | Drowning, hypothermia     |
|                        | Digging, moving sand and rock | Joint and bone deformities, muscle injuries, lacerations, back injuries, fatigue |
|                        | Transporting and processing ore, sitting, squatting | Musculoskeletal disorders, repetitive motion injuries, hand lacerations |
|                        | (iv) Other                   | Many including, concussion, blunt force, damage to eyes and ears, fractures, burns |
|                        | Accidents related to explosives | Many including, concussion, blunt force, damage to eyes and ears, fractures, burns |
|                        | Confined spaces              | Asphyxiation, unconsciousness |
|                        | Noise                        | Hearing loss             |
| Environmental          | (v) Personal characteristics | Magnification of health issues, no health care, addiction, beatings, sexual assaults, sexually transmitted diseases, behavioral disorders |
|                        | (vi) Incidental chemical exposure | Magnification of health issues, no health care, addiction, beatings, sexual assaults, sexually transmitted diseases, behavioral disorders |
|                        | (vii) Standing water in mines | Magnification of health issues, no health care, addiction, beatings, sexual assaults, sexually transmitted diseases, behavioral disorders |
|                        | Remote location, mosquitoes | Magnification of health issues, no health care, addiction, beatings, sexual assaults, sexually transmitted diseases, behavioral disorders |
|                        | (viii) Poor sanitation       | Magnification of health issues, no health care, addiction, beatings, sexual assaults, sexually transmitted diseases, behavioral disorders |
|                        | Contaminated drinking water  | Magnification of health issues, no health care, addiction, beatings, sexual assaults, sexually transmitted diseases, behavioral disorders |
| Human and Social       | (ix) Lifestyle/occupation interaction | Magnification of health issues, no health care, addiction, beatings, sexual assaults, sexually transmitted diseases, behavioral disorders |
|                        | Lawless remote locations     | Magnification of health issues, no health care, addiction, beatings, sexual assaults, sexually transmitted diseases, behavioral disorders |
|                        | (x) Inadequate social network, chronic stress | Magnification of health issues, no health care, addiction, beatings, sexual assaults, sexually transmitted diseases, behavioral disorders |
|                        | Malnutrition                 | Stunted growth, other diseases |
|                        | Circle of poverty, little education | Chronic injuries over lifetime physical labor |
|                        | (xii) Violence, wars         | Many health impacts       |

The specific examples of hazards and health impacts in this table come from the report on Children in Hazardous Work (ILO, 2011).

to adult miners. Our companion paper (Schwartz et al., 2020) provides a detailed discussion of hazards and health risks on this table.

Table 1 is designed to be comprehensive and in so doing can obscure the fact that not every health impact should be expected at every ASM site. Several upcoming examples make it clear that context is important with respect to what is being mined, how that mining is occurring, and what jobs the children do. The examples also make clear that for many of the most concerning medical conditions, the health risks to children are poorly known.

There are concerns for children due to alcohol consumption (WHO, 2016), but little in the way of pertinent studies. There is anecdotal information from studies from DRC (GSS, 2013; Kelly et al., 2014; World
Bank, 2015) concerning alcohol and drug abuse in communities there, but little specificity for children and women. Given associations of adolescent girls and boys with ASM mining communities, inferences of health risks from alcohol and drugs exist. Interviews with adolescent boys (aged 12–17) in DRC confirmed both “men and boys were abusing alcohol” and that “adolescent boys and young men were turning to crime in order to obtain alcohol, drugs” (GSS, 2013). This is an area where further studies are needed.

3.3. Examples of Specific Health Impacts

There is little in the way of studies that connect the work that children do and incidences of occupation injuries and diseases. The following two sections provide descriptions through interviews with children working in Suriname and DRC.

3.3.1. Alluvial Gold Mining in Suriname (Heemskerk & Duijves, 2012)

The first study involved interviews with 167 children (163 boys, 4 girls) at three isolated gold mining areas in Suriname. Most children (89.3%) worked part time and regularly attended school. Ages ranged from 7 to 17 years (mean 13.4 years) with 18 children 10 years old or younger. Few girls were working because of parental concerns. Placer gold mining was mechanized with full-time crews mining hydraulically to remove overburden and to move gold-bearing sands to suction hoses, and then to sluice boxes. Children typically worked around the outside of the mechanized operations, in panning (83.8%; n = 167), removing stones and cutting roots in the pit (56.3%), and re-sluicing of tailings (49.1%). 12.6% of older children, mostly full-time workers, operated hydraulic-mining equipment. The remainder did various chores around the camp.

Interviews tabulated illnesses reported by the children and accidents on the job. The illnesses likely related directly to occupational determinants included aches and pains (23.3%; n = 167), skin issues (10.2%) and foot fungi (4.8%). Diarrheal problems (8.4%; n = 167) were likely related to drinking contaminated water at the camps. Vector-borne diseases included malaria (7.2%; n = 167) and leishmaniasis (<1%), which appear to be more common at ASM sites in South America (Villar & Schaeffer, 2019). Children also suffered to some extent from flus and colds (8.4%; n = 167), fevers (4.2%) and other ailments. Most children (73%, n = 163) never experienced injuries on the job. The most common injuries were various cuts (8.6%; n = 163), broken arms or legs (4.3%), and falls (4.9%). The atmosphere around the camp was reported as “rough and harsh,” but there was no specific psychological testing.

This collection of illnesses and accidents appears relatively mild. Heemskerk and Duijves (2012) considered that certain health risks (e.g., malaria) were like those faced at home. However, no specific medical information was available to establish problems associated with mercury use. Yet, 65.3% (n = 167) used mercury to concentrate gold. Although the study was not designed to measure potential health impacts from mercury, it reported a few symptoms consistent with mercury use.

Mechanized mining was the productive part of the mining efforts and would have been the main cause of serious accidents and pressure to produce gold. The accidents would be associated with the high-pressure water systems and cave-ins along the mining face of pits. To a significant extent, the children worked hard but were not involved with the high-risk operations. Instead, they worked at their own pace scavenging in the pit or already processed spoil, and on camp chores. Mercury use was the obvious and potentially most serious health risk.

Most of the children were Maroons, poor tribal peoples. They came from places close to mine sites and lived in large families, often without the father. They usually worked together with friends. Commonly, ASM provided the best opportunities for paying, part-time work, which provided spending money for these children. Most children attended school on a regular basis but were not doing well. However, slow progress appeared typical for children living in Suriname’s interior regions.

3.3.2. Cobalt-Copper, Kambove, DRC (World Vision, 2013)

The Town of Kambove is in Katanga Province in DRC, within a mineral-rich area known as the Central African Copperbelt. This region has the world’s largest collection of copper-cobalt deposits (Zientek et al., 2014).

World Vision interviewed children mining cobalt and copper. Children worked with adults reprocessing leftover tailings from industrial mining. Diggers, using picks and shovels, removed material from pits and
tunnels. Gatherers picked up material from the ground surface. Materials were transported to washing sites to prepare them for sorting. Washers used process water from the nearby plant to wet sieve materials.

Girls and boys worked together but with distinctly different jobs. Boys worked mainly as diggers or gatherers (67.5%; \( n = 37 \)), and girls worked mainly as washers (62.9%; \( n = 27 \)), along with a few boys (21.6%; \( n = 37 \)). The remainder worked as transporters and sorters. The list of health issues here included aches and pains (back and extremities), skin irritation, malaria, coughs, colds, and headaches. In terms of accidents, approximately half of the children interviewed (52.8%; \( n = 53 \)) reported being injured. The most common injuries included cuts (37.7%; \( n = 53 \)) and fractures (3.8%; \( n = 53 \)). The death of a child was also reported.

Of concern at Kambove was the potential for health impacts from exposure to cobalt, copper and uranium. Health interviews targeted questions toward symptoms of cobalt exposures and found: (i) body pain (86.8%; \( n = 53 \)) spread among diggers, gatherers, and washers; (ii) frequent and persistent coughs (66.9%; \( n = 53 \)) mostly with gatherers (11 of 12); (iii) skin irritation or illness (34%; \( n = 53 \)); nausea without vomiting (30.2%; \( n = 53 \)) with all 16 reporting persistent coughs; and (iv) eye pain or vision problems (24.5%; \( n = 53 \)) mostly with gatherers.

Although concerning, the results are equivocal in the sense that symptoms could have been related to hard work and ubiquitous dust. The report, however, recommended work to follow up the “cough-nausea” correlation, possibly indicating metal exposures (World Vision, 2013). Nevertheless, the potential risk of cobalt and uranium exposure was demonstrated in Kolwezi, about 125 km from Kambove. Mining of heterogenite (CoOOH) was ongoing in the middle of a suburb (Banza Lubaba Nkulu et al., 2018). Dust from mining near-surface deposits created significant exposure and uptake of cobalt, as evidenced by urine and blood samples. The highest concentrations (incidental exposure) were found in community (not ASM) children, living nearby, several with “exposure-related oxidative DNA damage” (Banza Lubaba Nkulu et al., 2018). The cobalt mineralization at Kolwezi was different than Kambove, likely creating different levels of exposure.

The study at Kambove lends support to a more nuanced vision of ASM in an African context. Authors recognized the importance of ASM as a livelihood activity to alleviate poverty in the face of de-agrarianization, and in supporting social roles of children in families (Hilson, 2010). They emphasized the inherent complexity in that the ASM issues of Kambove were different than those of eastern DRC, a region noted for violence and conflict. Second, they pointed to “disturbing media stores” and “activist campaigning” on abuses as oversimplifying issues that are more complex in detail. Finally, they acknowledged the need to move beyond the consequences to children to address the causes, for example, poverty absent social services and other job prospects, and limited education.

4. The Scope of Violence and Criminality

Since 1996, there has been formal acknowledgment of the association between global public health and violence (Krug et al., 2002). Violence in essence is when physical force or power is used against people, yourself, someone else, or larger groups, to create harm or even death. Here, we discuss three categories of violence: (i) interpersonal (e.g., family or community-member involvement), self-directed (for example, suicide, illicit or prescription drug abuse), and collective, involving larger groups (e.g., actors with political, economic, or other objectives). Overall, the topic includes a broad array of issues including physical, sexual, and psychological acts, as well as deprivation or neglect (Krug et al., 2002).

Our discussion here is organized graphically (Figure 3) around these three categories of violence, the various associated health risks, their relative prevalence, and finally the relative visibility of the problem, as indicated by the intensity of the red shading. Quantitative or specific descriptions are difficult again because of inherent data problems. In addition, violence is commonly unreported and unstudied in remote (rural) and politically marginalized areas. The criminal character of many activities within ASM also represents another huge impediment.

Visibility only becomes evident with collective violence, beginning with incidental information on improper labor practices and predatory lending (Figure 3). Most visible is broad-scale violence sometimes funded
by mineral wealth or associated with competition for control by guerilla and paramilitary groups, organized crime, and government.

The category of self-directed violence is concerned mostly with suicide (Krug et al., 2002). Our brief discussion here is mostly a placeholder to recognize its importance. Within ASM this topic is largely invisible and unstudied. Certain risk factors are likely present, feelings of helplessness and hopelessness, and alcohol and drug use. There are anecdotal indications of higher suicide rates for men and women in mining communities. One potential driver has been depression related to occupational exposures of mercury leading to suicide (Grum et al., 2006; Webster, 2012). Another particularly vulnerable population has been women suffering depression from poverty and partner abuse (GSS, 2013).

4.1. Interpersonal Violence and Children

Common examples of interpersonal violence include child abuse, spousal or partner abuse, and sexual abuse. All are associated with health impacts (Krug et al., 2002). First, we examine various forms of abuse and violence affecting children (Figure 3). Child neglect occurs when a parent with resources fails “to provide for the development of the child” (Krug et al., 2002). However, the deprivation because of poverty is not actual neglect. Children typically experience physical, psychological, and sexual violence (Krug et al., 2002).

Risk factors for violence affecting children included: (i) parents that are young, single, or poor, (ii) families that are large and living in poor communities with large population turnovers, and (iii) settings with larger violent conflicts (Krug et al., 2002). Certain of these conditions still exist in countries worldwide across many different occupations. However, in the case of ASM, these risk factors may be magnified in isolated mining towns, sometimes associated with other kinds of violence.

4.1.1. Observations From Domaine Marial, DRC (GSS, 2013)

Child violence within an ASM community was examined in and around Domaine Marial, DRC. This urban center is located near Kolwezi in the southern copper belt. Growth there was fueled by an influx of migrants looking to work in ASM. Most had left farming behind and available land around Domaine Marial was not sufficient to provide for food security.

Children and adolescent girls (ages 13–18) suffered from abuse, as well physical and psychological violence. Because of the time and place, readers should understand that situation there in DRC represented a worst case and was magnified by the endemic poverty among miners and their families. Houses were without electricity and most without running water. Children were at risk for hunger and malnutrition because of parental indifference, poor spending choices, and unemployment. Quantitative surveys of 40 adolescent girls indicated that 50% had not eaten in the past 24 h, 40% had not eaten in 2 days, and 10% had no recollection of when they last ate. Also, an important contributor to food insecurity was the added expenses of parental alcoholism and drug abuse (predominantly among fathers). Surveys showed that 45% of children (n = 30) and 60% of adolescent girls (n = 40) lived in households where alcohol and drug abuse were significant adult risk factors.

Other abuses were due to economic hardships and breakdowns in family structure. 45% of children (n = 30) and 60% of adolescent girls (n = 40) lived with a single parent (most often mother) or other caregivers. In some cases, men working at a distant site abandoned the family leaving a mother to run the household. Children were also vulnerable because of the loss of a parent from HIV/AIDS which left them as orphans. Other risk factors for abuse of an adolescent girl included (i) a spouse that remarried deciding not to care for children from a previous marriage, (ii) parents divorced and abandoning the children, and (iii) a polygamous father unable to support his whole family. Children and adolescent girls that moved into a new family

![Figure 3. The three main sources of violence are shown together the likely scope of the problem represented by position on the period, widespread at the bottom and limited toward the top. In brackets, we provide a qualitative estimate of the prevalence. The shading reflects no visibility of problems at the bottom and much more at the top.](image-url)
commonly reported physical abuse such as food deprivation, labor exploitation, and loss of personal items. Adolescent girls assumed an increased risk of sexual exploitation.

Children and adolescent girls were also at risk for physical and psychological abuse. For example, more than 65% of children \((n = 30)\) were slapped/had harmful items thrown at them, kicked, dragged, or beaten up. More than 60% of adolescent girls \((n = 40)\) either experienced the slapping or were hit by a fist or another hurtful object. Psychological abuses were common and included insults, belittlement, humiliation, scaring, and threats.

Many of these issues likely existed with poor families outside of ASM. The report \((\text{GSS}, \ 2013)\) however, mentioned factors exacerbating problems in Domaine Marial. It grew up as a boom town with a multicultural makeup leading to alienation and division, and absent support for newcomers. Jobs were in short supply and competitive, which led to idleness and a deep sense of helplessness and despondency among men. These issues were compounded by alcohol, drugs and crime. The influx of expatriate miners was seen as contributing to prostitution, leading to a HIV/AIDS prevalence rate of 7% of those tested.

### 4.2. Intimate Partner Violence

Intimate partner violence is most commonly experienced by a woman due to a husband or intimate partner. Such violence has been shown to be ubiquitous and independent of economic, social, cultural, or religious standings \((\text{Krug et al.}, \ 2002)\). It included behaviors leading to physical aggression, psychological abuse, forced sex or sexual coercion and various controlling behaviors \((\text{Krug et al.}, \ 2002)\). At times all these behaviors occurred together. Data in an African context for physical assault on a woman by a male partner \((\text{ever})\) ranged from 13% to 45% \((\text{median 27%})\) \((\text{Krug et al.}, \ 2002)\).

Certain actions by a woman commonly triggered a violent response from a man. Besides perceived transgressions such not obeying, arguing, not caring for children, asking about money etc., there was a traditional, cultural perception of physical violence as a husband’s right \((\text{GSS}, \ 2013)\). Risk factors for abusive behavior included young age, heavy drinking, depression, poor academic achievement, low income and more \((\text{Krug et al.}, \ 2002)\). These were shown to be relevant to ASM in the setting of mining towns, as are economic stress, poverty, and weak community sanctions.

In Domaine Marial, DRC, women suffered “physical and sexual violence, emotional abuse and controlling behaviors” from intimate male partners \((\text{GSS}, \ 2013)\). The incidence for physical violence and abuse sometime during a woman’s life was 100% \((n = 40)\) with 75% reporting sexual violence. The violent abuses included threatening, pushing, slapping, beating, punching, kicking, and threatening with a weapon \((\text{GSS}, \ 2013)\). Sexual violence was common \(>60\% \ (n = 40)\) including forced or unwilling sex, and degrading sex acts. These were not isolated events but a pattern of behaviors \((\text{GSS}, \ 2013)\). Women also suffered from psychological abuse such as insults, humiliation, intimidation and controlling behaviors from their partner. These behaviors were often a “predictor of physical or sexual assault on female partners” \((\text{GSS}, \ 2013)\). All 40 women interviewed reported some form of controlling behaviors keeping them from seeing friends or her birth family, anger at speaking with other men, etc. The main triggers for partner abuse were economic \((36\%, \ n = 40)\) and included money problems, unemployment, lack of food, and alcohol-related issues \((22\%)\).

The issues in Domaine Marial are like those reported by Krug et al. \((2002)\) associated with intimate violence elsewhere in a setting of poverty. The prevalence of abuse and violence in Domaine Marial was high relative to other surveys \((\text{Krug et al.}, \ 2002)\). The study \((\text{GSS}, \ 2013)\), however, pointed out that prevalent sexual violence and abuse was a norm for DRC more broadly, and that their sample size was small. A few factors likely exacerbated problems in Domaine Marial. These were mostly the same as those for child abuse and violence, discussed previously.

Fifty percent \((n = 40)\) of the women were injured from physical violence at least once with 10% injured five times or more \((\text{GSS}, \ 2013)\). Typical injuries included “bruises, abrasions, cuts, punctures, and bites” \((\text{GSS}, \ 2013)\). Thirty percent of women reported broken or injured teeth and almost one-third lost consciousness during a violent episode. Women also reported significant psychologic impacts to their well-being \((45\%; \ n = 40)\), with 45% considering suicide at some point. Interested readers can refer to Krug et al. \((2002)\) to find a comprehensive list of health problems around this abuse associated with intimate partners.
As one of the only assessments available, this case is helpful in illustrating potential problems. However, results are not generalizable because this is obviously a worst-case example with a small sample size and with no control. Moreover, ASM is so diverse and complex that uncertainty around intimate partner violence will be large. However, other studies point to concerns specific to ASM. For example, a study from eastern DRC reinforced the potential links between ASM and sexual violence (Rustad et al., 2016). Women living around ASM were at greater risk of sexual violence from both intimate and nonintimate partners. Risks were greater for violence from nonintimate partners in situations where armed actors were present (Rustad et al., 2016).

In an African setting, HIV/AIDS and sexually transmitted infections can also be problematic. For example, Adjei et al. (2014) studied the prevalence of HIV and syphilis among a population of migrant workers in a gold mining area of Ghana. The prevalence of HIV in their study group \( n = 164 \) was 6.3%, compared to 1.4% in Ghana’s general population. Women were substantially more impacted (12%; \( n = 50 \)) as compared to men (4.4%; \( n = 114 \)). The findings of higher risks for HIV communities of miners were “consistent with current literature.” The mobile population of migrants in Africa served as a bridge bringing diseases from more affected populations to less affected general populations (Adjei et al., 2014).

4.3. Collective Violence

4.3.1. Forced Labor, Debt Bondage, Community Security

A common narrative with ASM is a prevalence of forced labor, debt bondage and community violence. These carry potential physical, psychological health implications. Forced labor is defined by two conditions: (i) recruitment by force, fraud, or coercion, or threats and actions to force work, and (ii) no freedom to leave or restricted freedom of movement (Kelly et al., 2014). Debt bondage is collective violence related to debt. Loans cover needs like food, health care, mining tools etc. (Kelly et al., 2014). Debt bondage requires three conditions being met: (i) a debt exists, (ii) individuals are incapable of repaying, and (iii) they cannot leave (Kelly et al., 2014). Community violence considers actions by actors outside the family. Both forced labor and debt bondage have been proposed to be categories of human trafficking, which also include sex trafficking or child sex trafficking (Kelly et al., 2014).

The existence of human trafficking implies the existence of some kind of criminality around mining rather than simple artisanal mining. The actors can be smalltime players (claim owners, business owners) or a more powerful criminal organization organizing mining efforts (de Theije & Salman, 2018). In Colombia and Peru, these actors have been organized crime or criminal groups (Wagner, 2016). In the DRC, actors have included local armed groups, concession owners, and the military (Bafilemba & Lezhnev, 2015; FTS, 2013).

There is anecdotal evidence of forced labor and debt bondage within ASM. Women have been considered to be at risk for sex trafficking into prostitution (Hidron & Koepke, 2014) in mining communities and camps (Wagner, 2016). Aspects of forced labor and other criminality are considered to be associated with diamond mining in Angola and Sierra Leone; gold mining in Burkina Faso, Colombia, DRC, and Peru; ruby mining in Myanmar; and coal mining in Pakistan (USDOL, 2018; Wagner, 2016). Gold towns of the Madre de Dios region of Peru have been implicated in deceptive recruitment of men and women by concession holders, bar owners, and others (Wagner, 2016).

Issues of human trafficking in mining towns were the subject of a study in two eastern provinces of DRC (Kelly et al., 2014). This was a population-based study of 32 sites that involved interviews with 1,522 people, 74.2% males and 25.8% females, who were broadly associated with ASM. The study found that the prevalence of forced labor and debt bondage was small (3.7 and 2.6%, respectively; \( n = 1,522 \)), with minors more likely to have been victims of labor trafficking than adults (11 of 49 or 22%).

The results contradicted the prevalent perception of widespread human trafficking. One reason was that systematic data around human trafficking are lacking (Kelly et al., 2014). Second was that the standards for forced labor and debt bondage in their study are rigorous and requiring several conditions be met together (Kelly et al., 2014). Other studies may be informal with perhaps one of these conditions present, but not
all. For example, some studies might have considered forced labor simply to be an inability to leave the job or restricted freedom of movement, or with debt bondage an inability to pay off debt. The individual conditions by themselves were indicators of the “risks” of forced labor or debt bondage (Kelly et al., 2014). Finally, their study was a regional population-based study rather than one designed to sample conditions at a particularly egregious site.

Interviews determined that 17% ($n = 1,522$) were at risk for forced labor. In the case of debt bondage 44.7% were at risk because they had debt, 13.7% because they could not pay back their debt, and 9.3% because they did not feel free to leave or were restricted from leaving. The study also found extensive vulnerability to exploitation from powerful actors, the army, and armed groups. Women were at risk for sexual exploitation in the setting of violent towns (Kelly et al., 2014).

Security emerged as an important problem with approximately two-thirds of participants robbed at gunpoint in one year. Sites controlled by armed groups were more secure than those without such control (Kelly et al., 2014). No data were collected on health-effects associated with human trafficking in eastern DRC, but there was daily alcohol consumption by men (50.4%; $n = 1,129$) and women (21.4%; $n = 393$).

### 4.3.2. Fighting Over Valuable Resources

The escalating price of commodities, especially gold, has attracted the interest of other actors, including local gangs, “domestic and transnational organized criminal groups” (Soud, 2019), and insurgent and terrorist groups. Neither these other actors nor corrupt government and military entities do mining. They work by extortion, forcibly taking over the unorganized work force and local businesses. They provide security, oversee logistics, equipment leasing, prostitution, and drugs (Wagner, 2016). In effect, they transform traditional small-scale artisanal mining into an illegal, larger-scale mining enterprise. Profit comes by extorting a share of the gold or commodities produced (Soud, 2019) and the cash flows in local economies, and by controlling the supply chain. Sometimes, they become de facto local governing authorities, maintaining order and settling disputes when the official government lacks the capacity to govern these sites (de Theije & Salman, 2018). Thus, takeovers did not necessarily come along with chaos, “mobocracy,” and a “complete explosion of violence” (de Theije & Salman, 2018). For the artisanal miner, there are rules to be followed, taxes to be paid, and “predictability” concerning their employment (de Theije & Salman, 2018).

The impact of criminal takeovers on ASM are complex and different than common perceptions. Latin America is noteworthy for the manner in which gold mining has evolved from many traditional ASM activities to larger, criminal enterprises that involve violent actors looking to diversify their historical business, for example, drug trafficking, kidnapping, etc. Masse and McDermott (2017), for example, examined alluvial gold mining in the department of Choco, located along the west coast of Colombia, around Quibdo (Figure 4). In this area, traditional ASM had historically involved generations of Afro-Colombian communities and indigenous peoples. This pattern began to change in the 1980s with an influx of migrants with funding to mechanize small-scale mining operations. These increasingly illegal operations subsumed the artisanal miners and their communities. Local miners were left to pan leftovers, to work as “indentured labor” (Masse & McDermott, 2017), or to find other jobs. This changing management style for gold mining has impacted local peoples economically and caused environmental damages.

Valuable gold resources also attracted the attention of Marxist revolutionary groups such as the Revolutionary Armed Forces of Colombia (FARC) and National Liberation Army (ELN), and organized crime groups, like the Urabenos. In Choco, these groups monitored and taxed all facets of mining in their areas and fought to protect territories (Masse & McDermott, 2017). Commonly, local communities became part of the collateral damage (Masse & McDermott, 2017).

The purpose, structures, and prosperity of these violent actors have evolved (Figure 4). FARC and ELN both began with political ambitions, using criminal activities for funding (Kelly et al., 2014). FARC demobilized in 2016; but holdouts quickly morphed into criminal groups, an example of the economization of conflict (Jackson, 2002). ELN also suffered setbacks and localized to factions focused on criminal income (InSight Crime, 2020). The Urabenos formed in 2006 but eventually became a network of local criminal groups, fighting a “bloody and bitter” turf war with ELN (InSight Crime, 2018).
Conditions surrounding ASM in Venezuela were similar to those in Colombia. Small-scale gold mining had also been criminalized under the auspices of violent groups. What was different in Venezuela was the complexity of operations that featured criminal participation by the military and government in Caracas and the ELN in the rich Orinoco Gold Arc (Soud, 2019). ELN had grown in influence by displacing weaker criminal groups and has the potential of destabilizing the region (Soud, 2019). These examples illustrate the growing risk of takeovers of traditional ASM by criminals in weak countries. Thus, instead of ASM being the engine to pull people out of poverty, profits are flowing to violent criminal groups.

Human health can be negatively impacted by worsened working conditions, collateral damage due to fighting among criminal groups and violence more generally, loss of employment or displacement. In the DRC, a large portion of the artisanal mining of gold was under the supervision of various armed groups including the military (Bafilemba & Lezhnev, 2015). The situation was much the same in parts of the central Sahel (Mali, Burkina Faso, and Niger) (ICG, 2019). However, the extent to which present production supports the activities criminal groups remains to be determined.

Health impacts associated with such violence has not been studied extensively. Violence in general is less evident because armed control is hidden (World Bank, 2015), but money is extracted from ASM by taxation, unfair market practices, and conspiracies with foreign corporations to keep prices low (Sovacool, 2019). In Zimbabwe, miners faced not only extortion from gangs, militias, and corrupt police, but also the threat of violent robbery or death by marauding “machete gangs” (Mining Zimbabwe, 2020). Interactions between artisanal miners and large mining interests have been complex, with occasional violent interactions with security forces that included injuries and death (Katz-Lavigne, 2019; Sovacool, 2019).

### 4.3.3. Wars

The last area of discussion is war (Figure 3). In studying the economics of war in resource-rich countries, Jackson (2002) noted a tendency toward “the economization of the conflict.” While economic drivers may not be the initial cause of conflict, its goals have been shown to shift with time toward profit and economic
opportunities (Jackson, 2002). The specific example was the second Congo conflict from 1998 to 2003 (Jackson, 2002) with reported death estimates ranging from 2.5 to 3.5 million people (Herp et al., 2003; Zapata, 2011). Fighting for the Congo morphed into military strategies to control the mineral and timber wealth of eastern DRC (Jackson, 2002).

Hawkins (2004) called this war a “stealth conflict.” It was unnoticed by the international community, in spite of the involvement of eight countries and affiliated actors, with deaths second only to those of WWII. Another stealthy feature was the cause of deaths. Casualties were not from physical violence but from “starvation and disease” (Hawkins, 2004). There is no specific information about the health of artisanal workers during these times. However, the public-health system of the time was near total collapse (Herp et al., 2003). Surveys of the worst areas showed significant mortality of children under 5 year of age due to malnutrition, diarrhea, and suspected malaria. These problems were common with older people in other places in addition to respiratory infections. People caught up in the fighting, commonly experienced looting, destruction of property and cases of “physical assaults, torture, imprisonment, and sexual abuse” (Herp et al., 2003).

5. Concluding Comments

Studies of ASM and health (WHO, 2016) in areas of affecting children’s health and the impacts of criminality and violence are frustrated by a lack of information. What information is available commonly relates to valuable resources, gold, diamonds, and strategic metals. Yet, for these activities, there is tremendous variability and complexity making it difficult to get beyond long lists of potential hazards and potential health impacts. Other areas, like coal or sand mining, remain largely unstudied.

Our review examined health implications of ASM for children working at sites in Suriname and DRC. These studies helped to dispel the perception that every hazard and health risk listed in Table 1 are present at every mining site. In Suriname children mostly worked away from the mechanized mining, essentially scavenging for leftover gold, and doing camp chores at their own pace. That work was hard, but at a cursory level, health problems were apparently minor. However, given mercury use, there is an obvious risk for more serious problems. In Kambove, DRC, the ASM effort was also scavenging, involved with picking copper-cobalt materials out spoil. Again, the work was hard with superficial injuries, one reported death, and some indication of health effects from metal exposures.

Worker and community interviews provide useful information about accidents and other common ailments. However, they cannot replace formal medical screenings for serious health problems. For gold mining, chronic exposure to mercury vapor and methyl mercury are significant risk factors (WHO, 2016). Inhalation of mercury vapors created during heating of mercury-gold amalgams is the primary exposure pathway, leading to kidney dysfunction, tremors and a variety of neurological problems (WHO, 2016). Studies looking specifically for mercury exposures in artisanal mining find them. For example, in Madre de Dios, Peru, those processing mercury-gold amalgams had higher urine mercury levels than other groups (Yard, 2012). Also significant was the general incidental exposure of the nonmining community to both elemental mercury, but also methylmercury, possibly from fish consumption (Yard et al., 2012). Other community impacts of mercury use are evident in Colombia, where security issues have driven the processing of gold into towns (Webster, 2012).

For cobalt, biomonitoring in Kasulo, DRC found occupational and incidental community exposures with elevated uptake of cobalt (Banza Lubaba Nkulu et al., 2018). Children were more impacted than adults. Concentrations of cobalt in urine sampled from community children (not mining) were higher than diggers at work nearby mining cobalt (Banza Lubaba Nkulu et al., 2018). If the goal with restrictions around children working is health, then other impacted populations of children need to be addressed.

There are likely health effects related to criminality and violence. The results from detailed interviews from Domaine Marial, DRC, with respect to violence to children and intimate women partners are sobering but require cautious interpretation. Without a control group, it is difficult to conclude that this ASM community is significantly different than other poor communities in terms of familial and intimate partner violence. As noted earlier, there are reasons to think Domaine Marial to be among worst cases within ASM.
Population studies in eastern DRC found little prevalence of forced labor and debt bondage. Moreover, the risks were relatively small, except that people commonly borrow money. The control of criminal and/or military groups can be hidden so that mining proceeds without overt violence and chaos (de Theije & Salman, 2018). The health effects seem less about physical punishment, and more around the health problems of being poor with profits advancing other causes. Poverty was exacerbated by various types of taxation and unfair market practices (Sovacool, 2019). In the DRC, actual physical violence came from occasional violent interactions of artisanal miners working on concessions titled to foreign corporations (Katz-Lavigne, 2019; Sovacool, 2019).

The growing use of expensive equipment in small-scale mining has several consequences. Often, the costs involved with such mining are beyond the financial capacity of traditional miners and tend to marginalize their participation. For example in Colombia (Masse & McDermott, 2017) and Suriname (Heemskerk & Duijves, 2012), these larger operations often have ignored the historical rights of artisanal miners to control areas. Artisanal miners are still working but opportunities are diminished. They have become laborers on mining crews or work in less profitable operations like panning tailings (Masse & McDermott, 2017).

Increasingly mechanized placer operations are efficient in processing much larger volumes of material in much shorter periods of time. This was the case, for example, with the hydraulic mining of gold in Suriname (Heemskerk & Duijves, 2012) and Colombia (Masse & McDermott, 2017). The scale of environmental disruption was substantial, much greater than traditional ASM (Masse & McDermott, 2017). For example, land disruption and mercury contamination associated with gold mining in Madre de Dios area of Peru have attracted negative press and the attention of governments who have sent police and military to shut down mining in the La Pampa region (Tollefson, 2020). Unfortunately, traditional small miners are swept into this disruptive process.

Another potential consequence of more efficient mechanized mining is the rapid exhaustion of minable deposits in local areas. Thus, the accelerated loss of dependable resources for peoples in an area like sub-Saharan Africa can disrupt long established social dynamics and make working in ASM more difficult logistically. A question for future work is how long growth in ASM sector can exist and what the pattern of decline might look like. For example, the industrial gold community is concerned that easily available and large gold deposits have been mined and replacing them has become increasingly difficult (Kerr, 2012).

There are hints of a decline in accessible resources that can be mined using ASM practices. New discoveries have attracted tens-of-thousands of people from hundreds or thousands of miles away to towns reminiscent of America’s “Wild West” of the nineteenth Century (Pellerin, 2017). For example, in Madagascar, the discovery of rubies in 2005 brought 15,000 miners to Moramanga in the tropical jungle. In 2016, sapphires attracted 45,000 people to the bush near Didy, Madagascar (de Grave, 2017). Pellerin (2017) described the three-year gold rush of 15,000 miners to two desert areas of Niger. Most miners found little gold and quickly left.

Our review here has illuminated areas of criminality and violence that have health implications. Given the indication of problems areas of violence and criminality additional work would be beneficial. As mentioned, problems of ASM can be mitigated by policy interventions that are firmly based in an understanding of what is happening in various countries, particularly with respect to aspects of health. For example, in the DRC, interviews with members of the mining communities led to useful policy recommendations for governments, large, industrial mining corporations, artisanal miners, and the electronics industries (Sovacool, 2019). With the mercury problem, Tschakert and Singha (2007) provided unique educational-based approaches toward safer handling. Similar academic efforts around policy and ASM are ongoing and have prospects of nurturing this important contributor to poverty reduction.

**Conflict of Interest**

The authors declare no conflicts of interest relevant to this study.

**Data Availability**

Data on the intensity and incidence of poverty (Figure 2) can be found below, (UNDP, 2019).
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