Assessing health impacts in complex eco-epidemiological settings in the humid tropics: Advancing tools and methods

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ABSTRACT

In the developing world, large-scale projects in the extractive industry and natural resources sectors are often controversial and associated with long-term adverse health consequences to local communities. In many industrialised countries, health impact assessment (HIA) has been institutionalized for the mitigation of anticipated negative health effects while enhancing the benefits of projects, programmes and policies. However, in developing country settings, relatively few HIAs have been performed. Hence, more HIAs with a focus on low- and middle-income countries are needed to advance and refine tools and methods for impact assessment and subsequent mitigation measures. We present a promising HIA approach, developed within the framework of a large gold-mining project in the Democratic Republic of the Congo. The articulation of environmental health areas, the spatial delineation of potentially affected communities and the use of a diversity of sources to obtain quality baseline health data are utilized for risk profiling. We demonstrate how these tools and data are fed into a risk analysis matrix, which facilitates ranking of potential health impacts for subsequent prioritization of mitigation strategies. The outcomes encapsulate a multitude of environmental and health determinants in a systematic manner, and will assist decision-makers in the development of mitigation measures that minimize potential adverse health effects and enhance positive ones.

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1. Introduction

Two-thirds of the human population now lives in the developing world (PRB, 2009) with a considerable number (1.4 billion people in 2005) living below a US$ 1.25/day level (Chen and Ravallion, 2008). It is estimated that more than a quarter of the burden of disease in developing countries is attributable to environmental risk factors such as poor sanitation, lack of hygiene, air pollution, or chemical and biological contaminations (WHO, 2006). Moreover, the climatic conditions in tropical and sub-tropical countries favour the transmission of vector-borne diseases (Guerra et al., 2006) and water-borne diseases (Lopez et al., 2006; Steinmann et al., 2006). Sexually-transmitted infections, particularly HIV/AIDS, are another key public-health concern, especially in sub-Saharan Africa (Asamoah-Odell et al., 2004; Oster, 2005). Communities living in these multilayered socio-economic and eco-epidemiological contexts are vulnerable to a host of negative health effects that can be caused or exacerbated by large infrastructure developments, such as projects in the extractive industry (Jobin, 2003; Birley, 2005; Utzinger et al., 2005; Traub, 2006; Upton, 2008) and water resources development and management (Lerer and Scudder, 1999; Fearnside, 2005; Giles, 2006; Erlanger et al., 2008a; Krieger et al., 2008).

Health impact assessment (HIA) of projects, programmes and policies embraces an interdisciplinary and multidisciplinary approach with the overall aim to influence decision-making so that negative health effects can be minimized and positive health effects enhanced (Kemm, 2001; Krieger et al., 2003; Joffe and Mindell, 2005). HIA considers a broad range of health effects and usually combines qualitative and quantitative methods to subsequently guide mitigation measures (Scott-Samuel, 1998; Lock, 2000; Joffe, 2003; Mindell et al., 2004). HIA has been developed over the past two decades (WHO, 1986; Scott-Samuel, 1998; Kemm, 2005) and has been institutionalized by many governments in the industrialised world (Hubel and Hedin, 2003; Scott-Samuel, 2005; Wismar et al., 2007). Although HIA holds promise as a sustainable tool and method to manage health impacts of large infrastructure developments in the tropics (Mercier, 2003; WHO, 2005; Bos, 2006; Singer and Castro, 2007), only few of the worldwide HIAs published in the peer-reviewed literature had an explicit focus on developing country settings (Erlanger et al., 2008b). At present, most low-income countries lack legislation for institutionalizing HIA (Caussy et al., 2003) and the paucity of readily available HIA tools and methods has limited the advancement of HIA as a sustainable tool and method to manage health impacts of large infrastructure developments.
methodologies is an important bottleneck for the promotion of HIA (Parry and Stevens, 2001; Cole et al., 2005; Putters, 2005). While guidelines and tools for implementing HIA have been developed and used in industrialised countries (WHO, 2009a), their use in the developing world is still limited and explained by contextual and legislative concerns. For example, in the developing world, only Thailand, India and Lao PDR have a regulatory requirement for performance of an HIA and Cambodia is in the process of developing a national HIA framework (Phoolcharoen et al., 2003; Vohra, 2007; R. Bos, personal communication). Of note, in India, the HIA requirement is only for water resources projects due to vector-borne disease concerns.

Here, we present an innovative HIA methodology, designed for a typical developing country context. Our methodology is developed within the frame of a large gold-mining project in the Democratic Republic of the Congo (DRC) which, in the second half of 2008, was in the planning stages (Divall and Winkler, 2008). For the structured analysis of baseline health data, we adopted an environmental health area (EHA) methodology that has been developed for private sector industrial projects (IPIECA, 2005; Erlanger et al., 2008a; IFC, 2009a). The affected population was stratified into discrete groups, according to judgements of differential exposure to project developments. Within the essential process of the impact assessment, a risk analysis matrix was developed that facilitates the articulation of evidence-based mitigation measures with a host of indicators utilized for subsequent prioritization. We believe that our HIA approach is broadly applicable, as it can capture important links between community health and industrial projects, and thus facilitates the promotion of a sustainable public-health policy in the developing world.

2. Project description

2.1. The Moto Goldmines project

Moto Goldmines Limited (MGL) is an Australian gold exploration and development company. In DRC, the objective of MGL is to move the Moto Goldmines project in the north-eastern part of the country from advanced exploration through feasibility and project development to bring the natural resource gold into production (MGL, 2009). The Moto Goldmines project is located in the Orientale province in Haute-Uélé district, in close proximity to the border of Uganda and Sudan. The geographic location of the project is shown in Fig. 1. The MGL concession covers an area of 1.841 km² in a rich gold-mining region with large-scale mining undertaken mainly by Belgian interests, dating back to the 1950s. When DRC became independent in 1960, the state-owned mining company Office des Mines d’Or de Kilo-Moto (OKIMO) continued with mining activities at a small scale.

MGL commenced with field exploration in January 2004 and defined a world class gold resource by identifying a number of unexploited gold deposits. In an independent technical review (Cube Consulting, 2008), the Moto Goldmines project development costs for the full-scale development phase were estimated at US$ 438 million. The Moto Goldmines project is a joint venture between OKIMO and Borgakim (a subsidiary of MGL), with Borgakim as the operator holding a 70% share of the project interest and OKIMO the remaining 30%. Furthermore, MGL will pay a lease premium and royalties on the gross revenues directly to the government of DRC. The environmental impact assessment (EIA) was initiated with the pre-feasibility study in 2006.

Fig. 1. Map showing the location of the Moto Goldmines project in the north-eastern part of DRC and major planned developments.
and underwent further reviews as part of the feasibility study in 2007 and the optimised feasibility study (OFS) in 2008. The social impact assessment (SIA) was launched together with the HIA and health risk assessment (HRA) in August 2008 within the scope of the OFS. The key feature of an HRA is appraisal of existing and project-induced potential health risks for the workforce. Thus the HRA concentrates on ‘inside the fenceline’ in contrast to the HIA which is ‘outside the fenceline’ and community centred.

2.2. Project developments

To enable large-scale gold development, mining sites and associated infrastructures must be established. Currently, there is little or no existing infrastructure (e.g. roads) as the project is located in a rural and underdeveloped part of DRC (Fig. 1). Key constructions include:

• open pits and underground mines;
• development of a process plant with the capacity of 2.8 million tons per year using a primary crusher followed by a closed carbon in leach circuit and flotation process;
• power generation facilities including a 20 MW hydroelectric station and a back up diesel generator;
• refurbishment of local roads and construction of new project roads (total length ~160 km), linking the project to the Ugandan border;
• water supply and treatment plants; and
• workforce housing, management facilities and related services (e.g. catering and recreation facilities).

In order to enter into full-scale development, it will be necessary to relocate a number of villages from the project area. Hence, a resettlement policy framework (RPF) was established, parallel to a full social and economic baseline assessment. In the RPF, the estimated number of impacted settlements and affected households is presented. This analysis includes (i) eligibility criteria for defining various categories of resettled communities; (ii) a legal framework reviewing the fit between DRC laws and regulations and International Finance Corporation (IFC) resettlement safeguard requirements; (iii) measures proposed to bridge any gaps between IFC and DRC requirements; and (iv) organizational procedures for the delivery of entitlements (RADS, 2009).

In 2007, the construction of the ~160 km connection road to Uganda commenced. Once the road is completed, accessibility of the study area will be enhanced as road transport in the region is extremely arduous to date. It is anticipated that considerable immigration by job seekers and/or small-scale service providers will then occur (IFC, 2009b). In-migration is likely to have an impact on the resident populations, including health impacts on communities living in close proximity to the connecting roads.

The project will become an important employer not only during the active construction period, but also during the operation phase. Furthermore, the total effect of the operation on local and regional employment might be substantial through multiplier effects (McMahon and Remy, 2001). However, the exact human resource requirements for the construction and operation of the project have yet to be determined. As with other large-scale development projects in the tropics, it will require a combination of local, national and expatriate staff to operate the project, based on the required skill sets (Utzinger et al., 2005).

2.3. Corporate objectives and legal framework

MGL states that they have committed to best practice in health, safety, community involvement and environmental protection (MGL, 2009). Nevertheless, no specific laws or regulations in DRC currently require an HIA or other studies be commissioned in order to predict future community-level health risks (and potential mitigation measures) from the project to local communities. However, the DRC Mining Code (2002) does specify that the project must outline a clear plan as to how a project will contribute to the development of the affected communities. The 2006 Mining Plan, which outlines the practical application of the mining code, specifies the importance of the mining sector in supporting the government in achieving the United Nations (UN)-based millennium development goals (MDGs) by improving the community wellbeing, the access to fundamental services such as clean water and quality medical care, the educational sector and the economical status.

The project may seek to acquire financing and loans from international development banks and is thus following the performance standards developed by the International Financial Institutions (IFIs). MGL will adhere to environmental and health performance standards and safeguard policies developed by IFC and adopted by the major IFIs in the 2006 Equator Principles (Equator Principles, 2006; IFC, 2006).

3. Health impact assessment

3.1. General considerations

To support IFC Performance Standard 4, which represents community health and safety, the IFC recently developed both detailed “Good Practice Notes” (GPNs) (IFC, 2008) and an HIA toolkit (IFC, 2009a) that presents the major framework that is commonly used for HIA (Joffe and Mindell, 2005). For the MGL HIA, a 6-step process was followed: (i) screening (preliminary evaluation to determine the necessity of an HIA); (ii) scoping (identifying the range of potential project-related health impacts and defining the terms of reference based on published literature, local data and broad stakeholder consultation); (iii) risk assessment (qualitative and quantitative appraisal of the potential health impacts in relation to defined communities and the project development, including stakeholder participation); (iv) appraisal and mitigation (development of a community health management plan (CHMP) based on the findings of the risk assessment); (v) implementation and monitoring (realisation of the CHMP including monitoring activities that allow for adaptation); and (vi) evaluation and verification of performance and effectiveness (key step to analyse the HIA process as a whole).

In view of the magnitude of the intended developments and the number of communities directly affected by the project, there was a clear need for an HIA for the Moto Goldmines project, and thus a scoping survey was conducted in May 2007 (Viliani and Divall, 2007). The study concluded that the health status in the local communities was poor and the health system extremely weak. For example, data from the local health district revealed that malaria and diarrhoeal diseases were very common, whereas other communicable diseases such as acute respiratory infections, HIV/AIDS, tuberculosis, meningitis and measles were also reported. Additionally, outbreaks of hemorrhagic fevers (Bausch et al., 2006) had occurred in the project area. Communities are widely scattered with very poor transportation networks. Access to the few, poorly equipped community health centres in the area is minimal. Discussion with local health authorities emphasized the paucity of quality health data for the area under investigation.

In order to better understand existing conditions, MGL is engaged in baseline health data collection. A two-pronged approach was adopted: (i) review of available secondary data; and (ii) collection of new, mainly qualitative data, using key informant interviews (KIs) and focus group discussions (FGDs). This rapid appraisal approach was designed to (i) facilitate a clearer definition of potential health data gaps; (ii) allow for stakeholder input; and (iii) align the HIA with the SIA and the EIA. The methodology of the full HIA thus follows an iterative process (Fig. 2). Each phase further enhances the full health
picture of the area, a deeper understanding of potential impacts is gained, and mitigation strategies can be fully developed once potential significant impacts are more clearly delineated.

### 3.2. Data collection

Evidence used in HIA includes published literature, local data and stakeholder input (Joffe and Mindell, 2005). In order to adequately perform health profiling of communities in the project area, multiple data collection methods were pursued. First, we reviewed secondary data, existing project documents, peer-reviewed articles and grey literature. About 90 sources were identified from which relevant information could be extracted for the baseline health status including the recently performed demographic and health survey (DHS) of the DRC (MEASURE DHS, 2008). Second, KIs were carried out with the three medical doctors who are based in the major regional health facilities (General Reference Hospital of Watsa, OKIMO General Hospital and Borgakim Medical Centre) and the one community health representative of the Moto Goldmines project. Third, two FGDs were carried out with local communities, one with young men (aged: 19–28 years) and the second with young women (aged: 17–25 years). For the KIs questionnaires, and for the FGDs, discussion guides were prepared on the basis of the scoping survey and key findings from the literature review (Hennink, 2007). Non-governmental organizations (NGOs) emphasizing public-health issues were absent in the project area, and hence this source of potential information could not be tapped. Additional KIs and FGDs, including additional stakeholders and older community members, will be carried out as part of further impact assessment of the physical and social environment.

### 3.3. Environmental health areas

As preparatory step for the risk assessment, the assembled baseline health data were analysed and stratified in a structured environmental health areas (EHAs) framework. The EHA framework is based on an analysis performed and published by the World Bank (Listorti, 1996; Listorti and Doumani, 2001). The World Bank analysis demonstrated that an almost 50% improvement in major health outcomes could be achieved by improvements in four sectors: (i) housing and urban development; (ii) water, food and sanitation; (iii) transportation; and (iv) communication (Listorti, 1996). Building upon this sectoral analysis and incorporating a broad perspective on “environmental health” led to the methodological development of a defined set of environmental health areas (IPIECA, 2005; Erlanger et al., 2008a; IFC, 2008, 2009a). The set of EHAs provides a linkage between project-related activities and potential positive or negative community-level impacts and incorporates a variety of biomedical and key social determinants of health. In this integrated analysis, cross-cutting environmental and social conditions that contain significant health components are identified instead of focusing primarily on disease-specific considerations as is frequently done in many biomedical analyses of potential project-related public-health impacts (Erlanger et al., 2008a). The 12 EHAs utilized in our analysis are summarized in Table 1.

In general, while each EHA may not be relevant for a given project, it is still important to systematically analyse the potential for project-related impacts across the various EHAs.

#### 3.4. Community profiling

The preceding SIA revealed that there were an estimated 11523 people in 2.315 households located in 20 villages that might be directly affected by the Moto Goldmines project and potentially need resettlement. Approximately 40 000 people live within a 3-km radius of the proposed major project development areas (synergy, 2009). The exact number of people that settled along the road to Uganda has yet to be determined. Most people are engaged in subsistence agriculture and artisanal mining, including migrant workers from

<table>
<thead>
<tr>
<th>No.</th>
<th>Environmental health area</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Communicable diseases</td>
<td>Transmission of communicable diseases (e.g. acute respiratory infections, pneumonia, tuberculosis, meningitis, plague, leprosy, etc.) that can be linked to inadequate housing design, overcrowding and housing inflation</td>
</tr>
<tr>
<td>2</td>
<td>Vector-related diseases</td>
<td>Mosquito, fly, tick and lice-related diseases (e.g. malaria, dengue, yellow fever, lymphatic filariasis, leishmaniasis, human African trypanosomiasis, onchocerciasis, etc.)</td>
</tr>
<tr>
<td>3</td>
<td>Soil-, water- and waste-related diseases</td>
<td>Diseases that are transmitted directly or indirectly through contaminated water; soil or non-hazardous waste (e.g. diarrhoeal diseases, schistosomiasis, hepatitis A and E, poliomyelitis, soil-transmitted helminthiases, etc.)</td>
</tr>
<tr>
<td>4</td>
<td>Sexually-transmitted infections, including HIV/AIDS</td>
<td>Sexually-transmitted infections such as syphilis, gonorrhoea, chlamydia, hepatitis B and, most importantly, HIV/AIDS</td>
</tr>
<tr>
<td>5</td>
<td>Food- and nutrition-related issues</td>
<td>Adverse health effects such as malnutrition, anaemia or micronutrient deficiencies due to e.g. changes in agricultural and subsistence practices, or food inflation; gastroenteritis, food-borne trematodiases, etc.</td>
</tr>
<tr>
<td>6</td>
<td>Non-communicable diseases</td>
<td>Cardiovascular diseases, cancer, diabetes, obesity, etc.</td>
</tr>
<tr>
<td>7</td>
<td>Accidents/injuries</td>
<td>Road traffic or work-related accidents and injuries (home and project related); drowning</td>
</tr>
<tr>
<td>8</td>
<td>Veterinary medicine and zoonotic diseases</td>
<td>Diseases affecting animals (e.g. bovine tuberculosis, swinepox, avian influenza) or that can be transmitted from animal to human (e.g. rabies, brucellosis, Rift Valley fever, monkey pox, Ebola, leptospirosis, etc.)</td>
</tr>
<tr>
<td>9</td>
<td>Exposure to potentially hazardous materials, noise and malodours</td>
<td>Exposure to heavy metals, pesticides and other compounds, solvents or spills and releases from road traffic; air pollution (indoor and outdoor); noise pollution and exposure to malodours</td>
</tr>
<tr>
<td>10</td>
<td>Social determinants of health</td>
<td>Including psychosocial stress (due to e.g. resettlement, overcrowding, political or economic crisis), mental health, depression, gender issues, domestic violence, ethic conflicts, security concerns, substance misuse (drug, alcohol, smoking), family planning, health seeking behaviour, etc.</td>
</tr>
<tr>
<td>11</td>
<td>Cultural health practices</td>
<td>Role of traditional medical providers, indigenous medicines, and unique cultural health practices</td>
</tr>
<tr>
<td>12</td>
<td>Health system issues</td>
<td>Physical health infrastructure (e.g. capacity, equipment, staffing levels and competencies, future development plans); programme management delivery systems (e.g. malaria, TB, HIV/AIDS-initiatives, maternal and child health, etc.)</td>
</tr>
</tbody>
</table>
other parts of DRC and neighbouring countries (synergy, 2009). Thirteen quarries are located in the immediate project area, and hence people proximal to them need to be resettled. The larger settlements are surrounded by a number of smaller satellite communities, mostly depending on subsistence farming. According to data from the local health authorities, 20% of the population is under the age of 5 years and 65% are below 15 years, showing an extremely young age structure that is typical for a developing country setting with high fertility rates and a short life expectancy (Lutz and Qiang, 2002).

To identify and quantify potential health impacts, an accurate population profile is needed and it is important to distinguish between differences in exposure and susceptibility (Mindell et al., 2001). Thus, besides a demographic profile of the at-risk population and the identification of the most vulnerable groups, it is crucial to understand how the development, construction and operation activities are likely to impact at both a household and community level. Impacts caused by resettlement, shifts in the social structures or influx triggered increases in population density need to be considered within the overall assessments. IFC performance standards and safeguard policies related to resettlement are extremely stringent and require a detailed household analysis before and after resettlement and relocation (IFC, 2006). Therefore, in our analysis, we stratified the relevant overall population into potentially affected communities (PACs), with PAC being defined as a community within a clear geographical boundary where project-related health impacts may reasonably be expected to occur. For the Moto Goldmines project, defining PACs is a formidable challenge because (i) community structures in the project area are very heterogeneous and complex; (ii) the project has a vast footprint; (iii) PACs are likely to change over the course of project implementation; and (iv) there are still changes in the project design, and thus its longer term implications are not fully known. This implies that the definition of PACs will need further adaptation as the project moves ahead; therefore, the specification of a PAC should be viewed as time-dependent as it will evolve over the project cycle. The findings of the social and economic assessments and the RPF will need to be carefully updated as this will allow linkage between the PACs and key demographic determinants such as age structure and population numbers. At this stage of the project the PACs were defined as:

- PAC 1 — resettled communities;
- PAC 2 — communities in the host areas;
- PAC 3 — Durba (due to proximity to project and new road constructions);
- PAC 4 — communities that are not directly affected by the project; and
- PAC 5 — communities along the road to the Ugandan border.

### 3.5. Risk analysis

It is useful to rank EHAs according to their comparative risk, as this facilitates prioritization of management actions. Thus, a quantitative or semi-quantitative rank ordering method is needed so that the significance of identified health impacts can be evaluated. This evaluation has been performed by drawing on (i) the available health data from the literature review; (ii) the information generated through stakeholder consultation; (iii) the knowledge of the project context and developments; and (iv) experience of previous HIA’s in similar settings. For the risk analysis, a 4-step procedure was developed that is illustrated on the risk assessment matrix (Fig. 3).

In step 1, the extent of the 4 different consequences — (i) intensity; (ii) duration; (iii) health effect — is rated according to the criteria set forth in Fig. 3. The output of this rating is a score between 0 and 3 for each consequence, depending on the estimated impact level: low (score = 0); medium (score = 1); high (score = 2); and very high (score = 3). In step 2, the scores of the consequences are summed up and based on the value the impact severity is assigned as follows: low (0–3); medium (4–6); high (7–9); and very high (10–12). In step 3 the likelihood of the impact to occur is assessed according to the following definitions: improbable (<40% likelihood of occurrence); possible (40–70% likelihood of occurrence); probable (70–90% likelihood of occurrence); and definite (>90% likelihood of occurrence). Step 4 entails the final significance rating, which is defined through the intersection of the impact severity and the likelihood of the impact to occur, as shown in

![Fig. 3. Risk assessment matrix including the four working steps of the appraisal (* likelihood of occurrence; significance rating: ♦ low; ♦♦ medium; ♦♦♦ high; ♦♦♦♦ very high).](image-url)
Fig. 3. Finally, the entire rating is based on a modified Delphi approach (Rowe and Wright, 1999), a technique intended for use in judgement and forecasting situations in which pure model-based statistical methods are not practicable.

A low significance indicates that the potential health impact is one where a negative effect may occur from the proposed activity; however, the impact magnitude is sufficiently small (with or without mitigation) and well within accepted levels, and/or the receptor has low sensitivity to the effect. Impacts classified with a medium significance and above require action so that predicted negative health effects can be mitigated to as low as reasonably practicable (HSE, 2008). An impact with high or very high significance will affect the proposed activity, and without mitigation, may present an unacceptable risk. While there are numerical risk-based environmental regulatory standards that govern biota, air, water and soil, a similar set of quantitative regulatory endpoints does not exist for public-health outcomes. This does not mean that health-based critical key performance indicators (KPIs) are not available; however, the “acceptability” of a change from baseline in a given set of KPIs is subject to wide interpretation. Communities and scientists may have very different interpretations of “acceptability” or “significance.” Hence, we feel that the use of KIs and FGDs is of vital importance as this begins a critical process of participatory stakeholder involvement (IFC, 2007).

In order to estimate the potential influence of the project on the various EHAs, and for subsequent prioritization of mitigation measures, the risk profiling is carried out for three distinct conditions, namely (i) baseline situation before project implementation; (ii) hypothetical situation of the project without any mitigation measures; and (iii) hypothetical situation of the project after implementing proposed mitigation measures. The latter scenario can be considered as analyzing potential residual impacts, a process that can only be assessed once mitigation measures have been articulated. There is no ranking or attempt at quantifying potential positive impacts. The significance is simply stated as positive (e.g. improvement of health services). If there is a negative accentuation of the health impact compared to the baseline condition, this is indicated in the risk assessment matrix. Similarly potential improvements due to mitigation are also documented.

3.6. Mitigation

Strategies are developed to monitor, evaluate and mitigate potential health impacts identified within the HIA. The overall strategies are organized around two fundamental public-health concepts: (i) health promotion (any intervention that seeks to improve or protect health by modifying human behaviours or through organizational, political and economic interventions designed to facilitate environmental adaptations); and (ii) disease prevention (any intervention that seeks to reduce or eliminate harmful factors). The prior risk analysis of the baseline condition and the project development without mitigation highlights that the EHAs are in need of extensive mitigation and is thus a good indicator of the required complexity and possible outlay of appropriate mitigation measures. Mitigation strategies also require PAC specific considerations. On the one hand, not all the EHAs may be of concern for mitigation for the individual PACs. On the other hand a separate risk analysis for a PAC may be indicated due to a particular susceptibility to a specific health impact. Further, the analysis of an EHA as a whole may be too vague in certain situations. For example, in the present study, potential health impacts due to malaria and arboviruses (EHA 2, i.e. vector-related diseases) were considered separately because of different predicted magnitudes within the project area.

4. HIA outcomes

To illustrate how our proposed HIA framework operates, the analysis of EHA 4 (i.e. sexually-transmitted infections, including HIV/AIDS) is presented. A summary of the significance of potential health impacts predicted along with key recommendations is discussed.

4.1. Baseline health data on EHA 4: sexually-transmitted infections, including HIV/AIDS

The first report of HIV in DRC dates back to 1959 (De Cock, 2001). In 2007 the national prevalence of HIV among adults aged 15 years and above was estimated at 1.3% (MEASURE DHS, 2008; UNAIDS/WHO, 2008). Higher prevalence rates have been reported from urban areas; a prevalence of 3.8% was found amongst women using antenatal services in Kinshasa, and 7.0% for Lubumbashi in 2004 (UNAIDS/WHO, 2008). However, disparities in HIV prevalence rates at different administrative levels are pronounced in DRC; hence it is difficult to obtain precise estimates at the local level where the Moto Goldmines project will be implemented.

HIV statistics for the project area were obtained from the Borgakim Medical Centre (BMC). BMC is the site medical service as well as the most effective health facility in the area, with about 25% of the patients consulted originating from the Borgakim workforce. In the first half of 2008, 28.8% of the HIV tests that were completed (n = 419) prior to blood transfusion, or based on clinical suspicion, and for patients who presented for voluntary testing and counselling (VCT) (n = 82) were positive (BMC, 2008). Although these statistics cannot be considered as a representative HIV prevalence rate for the entire population in the project area, the data indicate that HIV/AIDS is a major public-health concern. No additional data could be identified to verify these statistics and the BMC did not stratify according to age and gender. Importantly though, KIs and FGDs revealed that the knowledge and awareness related to HIV is insufficient and the levels of stigma and discrimination attached to HIV/AIDS are high. Further, all the participants emphasized that the artisanal mining activity in the area and the availability of money have led to an important level of transactional sex.

High-risk sexual behaviour is usually defined as having sexual intercourse with any persons other than a spouse or a regular partner. In the DHS, it was reported that 19% of women and 38% of men had at least one non-regular sex partner in the past 12 months (MEASURE DHS, 2008). In addition, only 16% of women and 26% of men reported the use of condoms during sexual intercourse. Although there is a lack of data regarding other sexually-transmitted infections, such as chlamydia, gonorrhoea, syphilis and trichomoniasis, high prevalences are commonly seen in areas associated with mining activity and in conjunction with low rates of condom use (Auvert et al., 2001; Gilgen et al., 2001). The number of consultations due to sexually-transmitted infections reported for the first term in 2008 by the BMC (2008) is exceptionally high (n = 458). In fact, it is only second to malaria (n = 868) as the most common cause for all consultations (n = 3,493). It is important to note that high-risk sexual behaviour and possibly the presence of an existing sexually-transmitted infection are thought to be important promoting factors for the further spread of HIV infection in African countries (Grosskurth et al., 1995; Mekonnen et al., 2005; Freeman et al., 2007). However, in a recent systematic review Potts et al. (2008) challenged these assumptions.

4.2. Impact assessment and mitigation in EHA 4

EHA 4 is a major public-health concern in the project area and implementation and operation of the Moto Goldmines project without accompanying mitigation measures could further exacerbate this situation. Key factors are the predicted in-migration of young men, and improved transportation corridors along which HIV could further spread, mainly through transactional sex. The current health care infrastructure is ill-prepared for effective management of sexually-transmitted infections in general, and HIV/AIDS in particular. All PACs could be impacted, including PAC 5, the communities that will settle
along the new road to the Ugandan border, where existing transmission rates of sexually-transmitted infections and HIV are, at least for the time being, likely to be lower than in the more densely populated project area. At present there is no “real road” that links these small villages/communities; however, the development of a new highway will significantly change the current situation.

The risk analysis for EHA 4 is summarized in Table 2 and the subsequent list contains an extract of the proposed mitigation measures:

- conduct a formal and detailed knowledge, attitude, practice and behaviour (KAPB) survey in the community to establish their existing understanding, perception and practice regarding sexually-transmitted infections with an emphasis on HIV/AIDS;
- develop information, education and communication (IEC) material based on the findings from the KAPB survey;
- develop a comprehensive HIV/AIDS management plan based on effective strategies (Potts et al., 2008) that are established within the WHO framework (WHO, 2009b);
- target commercial and opportunistic sex workers, long-haul truck drivers and security guards to decrease their risk of acquiring sexually-transmitted infections and HIV and to empower them for preventive action;
- support the establishment of a sufficient number of VCT sites in the region, and along the road to Uganda;
- enhance availability and social marketing of both male and female condoms both in the workforce and the community at large;
- establish and strengthen partnerships in the area with the local and national health authorities and agencies for reproductive health services; and
- analyse opportunities to improve access to anti-retroviral treatment (ART) and prevention of mother-to-child transmission.

4.3. Significance of potential health impacts and recommendations

Table 3 gives an overview of the significance of potential health impacts of the Moto Goldmines project, and serves as a tool for prioritization. Additionally, it highlights which of the 5 PACs are most impacted. This information needs to be constantly updated as new results from EIA, HIA and SIA and other sources become available.

Besides the proposed mitigation measures for each EHA, interim and early action recommendations were already put forth. First, due to the lack of reliable health data available in the project area, a more in-depth baseline health survey covering all of the PACs should be carried out. This would serve as pre-project health baseline for monitoring and surveillance of health impacts as project implementation and operation moves forward. Second, upgrading of the recording and reporting ability of the local health care service should be considered in the form of a health information management system. This would also build up a critical mass of human resources for subsequent monitoring and evaluation of health impacts. Third, influx, housing inflation and a possible increase in overcrowding in the area should be monitored. Fourth, the establishment of an integrated malaria control programme that incorporates both vector control and medical management of the disease should be implemented. Fifth, the development of a comprehensive HIV/AIDS policy and a related management plan is critical, including a stronger partnership with the national programme for the fight against HIV/AIDS and other sexually-transmitted infections for the prevention and treatment activities in the community. Opportunities to obtain funding from the ‘Global Fund to Fight HIV/AIDS, Tuberculosis and Malaria’ should be explored, particularly for the start-up of ART. Sixth, enhance access to adequate and safe supplies of clean water and improved sanitation in the communities. Moreover, in urban areas, collection and management of solid waste should be improved. Seventh,
a transportation management plan with the two different components ‘within the concession area’ and ‘to and from the concession’ should be developed.

5. Discussion

5.1. Advancing tools and methods for HIA in complex settings

We presented an innovative HIA methodology and feel that it is broadly applicable and fit for complex eco-epidemiological settings that are typical for the developing world. Developed within the frame of the Moto Goldmines project in DRC, we showed how our structured methodology can manage a large and diverse set of data to generate a set of outputs that can be utilized to guide mitigation measures. Indeed, the use of EHAs is a key feature for linking project-related activities with potential community-level impacts. Risk profiling in a standardized matrix then facilitated prioritization for subsequent mitigation measures. Especially for settings characterized by a large number of risk factors, the separate analysis of each potential health impact would render the assembly of a comprehensive output for the decision-makers a formidable challenge. The use of EHAs enables a clearly structured analysis from the outset; however, detailed investigation of specific health impacts is still easily performed, e.g., malaria instead of the broader EHA pertaining to vector-borne diseases in general. An advantage of using the EHA framework is the generation of clear and measurable outputs, which can be used by key decision-makers and stakeholders.

Stratification of potential health impacts by PACs must be viewed as an adaptive process, and hence at an early stage of the project predictions are preliminary. With new results from the EIA and SIA becoming available, this will strengthen the definition and delineation of the PACs, based on population profiles, including community sizes, risk factors, exposure and overall vulnerability. Sequentially, these factors can be incorporated into the risk analysis and mitigation procedure in an iterative procedure.

The risk analysis matrix represents the core of our methodology as it is a key step that influences the subsequent prioritization and mitigation processes. Potential health impacts were considered within five domains — extent, intensity, duration, health effect and likelihood — as essential to combine and balance the two important aspects of an HIA; (i) objective evidence; and (ii) subjective experience (Lock, 2000; Joffe, 2003), to render the outcome more robust. Thus, robustness is dependent on the quality and quantity of the available evidence and it is susceptible to assessor and rater bias. This issue has been discussed by the attribution assessment made in the ‘Yellow Rain’ case, which also applied a multiple-step strategy to analyse a complex mixture of qualitative and quantitative data (Katz and Singer, 2007). In comparison to the Yellow Rain study, the assessment of health impacts has the advantage that the determinants (consequences) can be defined in a straightforward manner, as we did in our risk assessment matrix, and thus assessor/rater bias can be minimized, though not excluded. In any case, the rating and predictive forecasting by means of a Delphi approach (Rowe and Wright, 1999) leaves always room for debate and disagreement over the relative rankings as it unavoidably involves subjective professional judgement.

The comparison of the estimated significance of an adverse impact without mitigation and the potential significance of the residual impact emphasizes the importance for mitigation of a health impact within a given EHA. Specific characteristics of the PACs can be fed into the risk analysis to further focus the analysis of the extent and intensity aspects. An additional option to improve the evidence of the risk analysis would be to link the predicted health effects with the severity or disability weights used for estimating disability-adjusted life years (DALYs) lost or averted (Fewtrell et al., 2008). However, this would require a detailed baseline burden of disease database.

The EHA framework is applicable to different levels of an HIA, i.e. from a rapid appraisal to a comprehensive assessment. Furthermore, the transparency of the methodology allows decision-makers to see both the subjective and objective bases of the impacts and proposed mitigations.

5.2. Predictions of potential health impacts

Regarding the magnitude of the Moto Goldmines project and the setting where the project is implemented, a host of adverse health effects is anticipated and therefore strongly indicates that a comprehensive HIA be considered (IFC, 2006). This argument is reinforced by the findings of the initial scoping survey (Viliani and Divall, 2007) and further underscored by the outcomes of the rapid appraisal HIA. For example, the impact on the local health services will be substantial. Potential project-induced in-migration (IFC, 2009b) could put further pressure on the already extremely limited health care services in the area. Nevertheless, strengthening and expanding the local health system hold promise for the project to induce lasting positive health outcomes. Several of the EHAs (e.g. EHA 1: communicable diseases; EHA 2: vector-related diseases; EHA 3: soil- water- and waste-related diseases; and EHA 4: sexually-transmitted infections, including HIV/AIDS) require careful mitigation of adverse influences of the project, otherwise as revealed by our risk analysis an aggravation of the baseline situation seems inevitable. Road traffic accidents are probably the biggest consideration for EHA 7. Development and operation of the project will clearly change traffic volumes and vehicle mixes. A massive increase in the number of light and heavy vehicles on either improved or new roads will have a significant impact; hence consideration of appropriate mitigation measures will be essential.

The HIA for the Moto Goldmines project has been undertaken as a prospective study at project planning stage. Timely analysis is crucial for any large-scale infrastructure development project in the developing world (Bos, 2006). Early assessment offers an opportunity for pre-execution advice on how the project activities, design or plans may be changed, modified or adapted in order to avoid or mitigate negative impacts and enhance anticipated benefits. In addition, the establishment of a transparent and scientifically-based pre-project health baseline will clearly facilitate the ability to monitor community and household level project-related impacts (Erlanger et al., 2008b).

6. Outlook and conclusion

As of early 2009, the first round of the revised feasibility study is completed and the synthesis of the outcomes will govern the next steps. In our view, the Moto Goldmines project has the potential to become a benchmark effort as it incorporates social responsibility, community involvement and environmental protection. The project could demonstrate whether “best practices” in a severely under-developed, tropical developing country setting can effectively produce a triple-win situation, i.e. for the local communities, the country and the operating company. We hope that the new flare-up of armed conflict in DRC that emerged in late 2008 will not thwart further progress of this and other projects.

In conclusion, we have presented an innovative HIA methodology that was designed for a developing country context. We believe that our approach could prove of considerable value for further advancing tools and methods of HIA in low- and middle-income countries, since it is aligned to be applicable in complex socio-economic and eco-epidemiological settings. The EHA framework bodes well since it focuses on the complex linkages between project-related activities and the potentially affected communities, and allows for proposing mitigation measures that are readily adapted to the eco-epidemiological settings.

Acknowledgements

We thank Paul Schmiede and colleagues from Moto Goldmines Limited for access to project-related data, the three medical doctors of
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