Health impact assessment in complex eco-epidemiological settings in the humid tropics

INAUGURALDISSERTATION

zur

Erlangung der Würde eines Doktors in Philosophie

vorgelegt der

Philosophisch-Naturwissenschaftlichen Fakultät

der Universität Basel

von

Mirko Severin Winkler

aus

Basel-Stadt, Schweiz

Basel, 2011

Genehmigt von der Philosophisch-Naturwissenschaftlichen Fakultät
auf Antrag von
Prof. Dr. Jürg Utzinger, Dr. John Kemm, und Prof. Dr. Gary Krieger

Basel, den 24. Mai 2011

Prof. Dr. Martin Spiess
Dekan der Philosophisch-
Naturwissenschaftlichen Fakultät

Summary

Background: Health impact assessment (HIA) is an interdisciplinary approach that aims at predicting and managing potential positive and negative health effects of policies, programmes and projects on affected communities and populations. HIA has been developed over the past two decades and became an integral part of public health policies of many governments in the industrialised world. However, in many developing countries, where two thirds of the world's population are now concentrated, HIA has yet to be institutionalized. This is particularly important in view of the high burden of disease and pronounced health inequalities in tropical areas. Furthermore, it is anticipated that major drivers of global change, such as population growth and urbanisation, increasing demand in natural resources and regional climate change, will have severe health implications, particularly in the developing world. This will require modification of existing, and development of new policies and programmes in various sectors. Thus HIA, utilized as a systematic approach for the assessment of health impacts, is an important tool and strategy to assist decision-makers for health promotion in low- and middle-income countries. Against this background, the lack of well-defined HIA methodologies that are designed for the purpose of a typical tropical country context was identified as an important constraint for the promotion of HIA in developing countries.

Objectives: Four specific objectives were pursued in this PhD: (i) to develop and advance HIA tools and methods that are readily adapted to complex eco-epidemiological settings in the humid tropics; (ii) to validate these tools and methods within the frame of HIA of industrial development projects in developing country contexts; (iii) to systematise key findings and discuss lessons learned so that the tools and methods become available to HIA practitioners; and (iv) to deepen the understanding of the complex linkages of project-related activities with affected communities and their environment.

Research partnership: This PhD project was carried out within the frame of a public-private partnership between the Swiss Tropical and Public Health Institute (Swiss TPH) and NewFields, an international consultancy company with long-standing expertise in HIA in developing countries. Collaboration in selected HIA assignments for private and public clients of NewFields served as platforms for the present research.

Method: The PhD thesis entailed field work in the frame of 11 HIA for different industrial development projects, particularly in sub-Saharan Africa. Each of these HIA assignments held the opportunity for the development, validation and consolidation of tools and methods according to the respective stage of the HIA process.

Results: Over the course of this PhD thesis, a HIA-trilogy was generated, consisting of three parts, each of which is built on a case study and introduces a set of methodological contributions to the overall HIA process in complex eco-epidemiological settings in tropical regions. In the first part, the concept of environmental health areas (EHAs) is used and further developed, potentially-affected communities (PACs) are stratified, and different information sources are employed, including participatory methods, to obtain quality baseline health data. Feeding these data into a novel risk analysis matrix facilitates the ranking of potential health impacts for subsequent prioritization of mitigation strategies. The tools were developed within the frame of a HIA of a large gold mining project in a remote area of the Democratic Republic of the Congo. The outcomes encapsulate a multitude of environmental and health determinants in a systematic manner.

In the second part, the centrality of the scoping phase is illustrated with specific examples drawn from an ongoing HIA of a large iron ore project in the Republic of Guinea. Data from stakeholder consultations, limited community involvement and a desktop review of available health statistics is integrated via an analytical framework for the systematic selection of health outcomes and determinants of major concern. A subsequent gap analysis is utilized to assess the need for further baseline health data collection and to facilitate the specification of a set of potential indicators and strategies to inform the required evidence-base. It is argued that this more rigorous approach to scoping than heretofore is a prerequisite for the planning and implementation of any baseline health survey as part of the overall HIA process in multilayered socio-economic and eco-epidemiological contexts.

Last but not least, in the third part, a modular cross-sectional baseline health survey study design, which has specifically been developed for HIA of industrial development projects in tropical areas, is presented. The modular framework can be readily adapted to the prevailing eco-epidemiological characteristics of a given project setting. A broad set of key performance indicators (KPIs) is underlying the modular methodology, covering a multiplicity of health outcomes and determinants at different levels. Findings of a baseline health survey carried out in the project region of the aforementioned iron ore mining project in the Republic of Guinea illustrate the use and value of the proposed methodology. This study demonstrates that quantitative assessment of health impacts is an important feature for realising the full potential of HIA as it will not only allow to further our understanding of how communities are affected by projects, but also improve the predictive validity of HIA in areas where demographic, ecological, environmental, epidemiological, health and socio-economic data are sparse.

Conclusions: The systematic HIA approach that evolved within the frame of this 3-year PhD thesis bodes well with the four core values of HIA – ethical use of evidence, democracy, equity and sustainable development – and is thus an important methodological contribution to the science of HIA. Moreover, the developed HIA methodology lends itself well to routine HIA of large-scale development projects in a tropical country context, especially since it has proven to be broadly applicable to different types of projects and environments. However, in order to yield the full potential of HIA in developing countries, similar research efforts are needed on policy and programmatic level in different sectors. At the same time we propose that the World Health Organization and the HIA community at large should make any effort possible to further advocate and expedite excellence and capacities in HIA that are integrated in academia and governments of developing countries.

Zusammenfassung

Hintergrund: Für den englischen Begriff 'health impact assessment' (HIA) gibt es im Deutschen unterschiedliche Übersetzungen, darunter Formulierungen wie ‚gesundheitliche Folgenabschätzung', ‚gesundheitliche Wirkungsbilanz' oder ‚Gesundheitsverträglichkeits-prüfung'. Bisher hat sich keiner dieser Begriffe allgemein durchgesetzt, weshalb hier die Abkürzung HIA verwendet wird. HIA ist ein interdisziplinäres Verfahren zur Vorhersage und Einschätzung von positiven und negativen gesundheitlichen Folgen von Strategien, Programmen oder Projekten auf betroffene Bevölkerungsgruppen. Die HIA-Methode wurde in den vergangenen zwei Jahrzehnten entwickelt und wurde zum integralen Bestandteil des öffentlichen Gesundheitswesens in westlichen Industrieländern. In vielen Entwicklungsländern, wo zwei Drittel der Weltbevölkerung lebt, muss die HIA-Methode noch institutionalisiert werden. Dies ist, in Anbetracht der hohen Krankheitslast und der sozialen Ungleichheiten in Ländern mit niedrigem Einkommen, besonders wichtig. Zudem werden sich Einflussfaktoren des globalen Wandels wie Bevölkerungswachstum, zunehmende Urbanisierung, steigende Nachfrage nach natürlichen Ressourcen und Klimaerwärmung besonders stark auf Entwicklungsländer auswirken. Gravierende Implikationen im Gesundheitsbereich sind Folgen dieser globalen Wandlungen. Dies wird unter anderem dazu führen, dass eine Vielzahl von Strategien, Programmen und Projekten in verschiedenen Bereichen neu entwickelt oder den sich verändernden Bedingungen angepasst werden müssen. Daher wäre das HIA als systematisches Verfahren für die Einschätzung von Auswirkungen auf die Gesundheit eine wichtige Strategie für den Entscheidungs-findungsprozesses zur Gesundheitsförderung in Entwicklungsländern. Allerdings wurde der Mangel an spezifischen Methoden, die gezielt auf die Rahmenbedingungen in tropischen Ländern ausgelegt sind, als eine der Einschränkungen identifiziert, die dazu führt, dass die HIA-Methode in Entwicklungsländern heutzutage kaum Anwendung findet.

Ziel: Der vorliegenden Dissertation liegen die vier folgenden Ziele zugrunde: Erstens müssen Verfahren und Methoden entwickelt und angepasst werden, die geeignet sind, die vielen Faktoren in komplexen öko-epidemiologischen und sozio-ökonomischen Bedingungen, wie sie in den Tropen anzutreffen sind, zusammen zu führen. Zweitens wären die entstandenen Verfahren und Methoden im Rahmen von industriellen Entwicklunsprojekten in Entwicklungsländern zu validieren. Drittens sollten bestätigte Verfahren systematisiert, diskutiert und zukünftigen HIA-Fachleuten zugänglich gemacht werden. Viertens galt es, das

Verständnis über die komplexen Wechselwirkungen zwischen den Aktivitäten von industriellen Entwicklungsprojekten und der betroffenen Bevölkerung zu vertiefen.

Forschungspartnerschaft: Die vorliegende Arbeit wurde durch eine öffentlich-private Partnerschaft zwischen dem ‚Schweizerischen Tropen- und Public Health-Institut' (Swiss TPH) und NewFields, einem US-amerikanischen Beratungsunternehmen mit langjähriger Erfahrung im Bereich von HIA in Entwicklungsländern, ermöglicht. Ausgewählte HIA-Projekte für öffentliche und private Kunden von NewFields dienten als Grundlage für die vorliegende Forschungsarbeit

Methode: Insgesamt umfasst die Dissertation Feldarbeit im Rahmen von 11 verschiedenen HIA-Aufträgen für industrielle Entwicklungsprojekte, insbesondere in Afrika. Jedes dieser Projekte bot die Gelegenheit für die Entwicklung, Validierung und Konsolidierung von Verfahren und Methoden gemäss der entsprechenden Phase im HIA Prozess.

Ergebnisse: Im Verlaufe der Arbeit an der Dissertation ist eine ‚HIA-Trilogie' entstanden. Jeder Teil ist auf einem Fallbeispiel aufgebaut und präsentiert methodologische Beiträge zum HIA-Prozess im multifaktoriellen Kontext tropischer Länder. Im ersten Teil wird das Konzept von ‚Umwelt-Gesundheits-Bereichen' angewandt und weiter entwickelt, potentiell betroffene Bevölkerungen werden kategorisiert, und für die Beschreibung der gesundheitlichen Grundbedingungen werden verschiedene Informationsquellen wie unter anderem partizipative Erhebungen konsultiert. Für die Einschätzung der potentiellen Auswirkungen dieser Interventionen auf die Gesundheit werden die gewonnenen Daten mit einer neuartigen Risikoanalyse-Matrix verarbeitet, um somit Prioritäten für den Massnahmenkatalog zu setzen. Diese Methoden wurden im Rahmen eines HIA für ein gross angelegtes Goldminen-Projekt in einem abgelegenen Gebiet der Demokratischen Republik Kongo entwickelt und geprüft.

Im zweiten Teil wird anhand eines Eisenerzminen-Projekts in der Republik Guinea die zentrale Relevanz der ‚scoping' Phase als zweitem Schritt im HIA-Prozess veranschaulicht. Für die systematische Selektion von massgebenden Gesundheitsauswirkungen werden Daten, die mit partizipativen Methoden generiert und durch lokale Gesundheitsstatistiken ergänzt wurden, in eine analytische Datenbank integriert. Die anschliessende Lücken-Analyse dient der Beurteilung der Notwendigkeit eines allfälligen ‚baseline health survey' (Basis-Gesundheitszustand-Studie) in der betroffenen Bevölkerung und ist bei der Bestimmung von potentiellen Indikatoren und Datenerfassungsstrategien behilflich. Es wird demnach dargelegt, dass dieses rigorose ‚scoping'-Verfahren eine Voraussetzung ist für die Planung und Durchführung des ‚baseline health survey' als Bestandteil des HIA-Prozesses in multifaktoriellen Kontexten in den Tropen.

Im dritten Teil wird ein Studienkonzept für modulare ‚baseline health surveys' präsentiert, das gezielt für das HIA von industriellen Entwicklungsprojekten in Entwicklungsländern entwickelt wurde. Der modulare Aufbau kann nach Belieben den öko-epidemiologischen und sozio-ökonomischen Charakteristika eines gegebenen Projekts angepasst werden. Eine breitgefächerte Auswahl an gesundheitsrelevanten, sozio-kulturellen und ökologischen Indikatoren bildet die Grundlage der modularen Methodologie. Ergebnisse eines ‚baseline health survey', der in der Region eines Eisenerz-Projektes in der Republik Guinea durchgeführt wurde, dienen der Veranschaulichung der Funktion und des Nutzens des vorgeschlagenen Studienkonzepts. Des Weitern demonstriert diese Fallstudie die Wichtigkeit quantitativer Datenerhebungs- und Beurteilungsmethoden für die Realisierung des vollen Potentials des HIA. Denn diese tragen nicht nur dazu bei, unser Verständnis darüber zu erweitern, wie die Gesundheit von betroffenen Bevölkerungen durch industrielle Entwicklungsprojekte beeinflusst wird, sondern verbessern auch massgeblich die Gültigkeit von Vorhersagen des HIA in Gebieten, wo demographische, epidemiologische, ökologische und sozio-ökonomische Daten kaum vorhanden sind.

Schlussfolgerungen: Das systematische HIA-Verfahren, welches im Verlaufe dieser 3-jährigen Dissertation entwickelt wurde, steht im Einklang mit den vier Grundwerten der hier diskutierten Methodologie (i.e. der ethische Gebrauch von Evidenz, Demokratie, Gleichheit und nachhaltige Entwicklung) und ist daher ein substantieller wissenschaftlicher Beitrag zum HIA. Zudem eignet sich das entwickelte Verfahren für die Routineanwendung in HIA von industriellen Entwicklungsprojekten in tropischen Ländern, insbesondere da es sich in den unterschiedlichsten Bedingungen bewährt hat. Um jedoch das Potential der HIA-Methode in Entwicklungsländern vollends auszuschöpfen, sind weitere Forschungsarbeiten im Bereich von Strategien und Programmen im öffentlichen Sektor nötig. Zugleich schlagen wir vor, dass die Weltgesundheitsorganisation in Zusammenarbeit mit HIA-Fachkräften ihre Bemühungen für die Förderung des HIA-Verfahrens verstärken und Fachkompetenzen ausbilden, die in Hochschulen und Regierungen von Entwicklungsländern integriert sind.

Résumé

Introduction : L'évaluation d'impact sur la santé (EIS) est une approche interdisciplinaire dont le but consiste à prédire et surveiller les effets potentiels, positifs ou négatifs, d'une politique, d'un programme ou d'un projet sur la santé d'une population. L'EIS s'est développée ces vingt dernières années pour devenir un élément important des politiques de santé de nombreux gouvernements dans les pays industrialisés. Cependant, dans les pays en voie de développement, où vivent par ailleurs les deux tiers de la population mondiale, l'institutionnalisation de l'EIS reste inachevée. Cela est particulièrement important comte tenu de la pression énorme qu'exercent les maladies et les inégalités sanitaires, notamment dans les pays tropicaux. De plus, nous pouvons nous attendre à ce que les majeurs forces du changement global, tels que la croissance de la population et l'urbanisation, la demande croissante en ressources naturelles et les changements de climats au niveau régional, aient de lourdes conséquences sur la santé des populations, particulièrement dans les pays en voie de développement. Cette évolution exigera la modification des politiques actuelles ainsi que le développement de programmes et de projets dans différents secteurs. L'EIS, en tant qu'approche systématique dans l'évaluation des impacts sanitaires, représente ainsi une stratégie importante d'assistance à la promotion de la santé dans les pays en développement. Dans ce contexte, le manque de méthodologies d'EIS bien définies et applicables aux situations rencontrées dans les pays tropicaux a été identifié comme le facteur limitant d'une promotion plus globale de la démarche de l'EIS.

Objectifs : Cette thèse de doctorat comporte 4 objectifs: (i) développer et améliorer les outils et les méthodes d'EIS qui s'adaptent facilement aux situations complexes rencontrées dans les pays à faible et moyen revenu ; (ii) valider ces outils et ces méthodes dans le cadre de projets de développement industriel mis en place dans des pays tropicaux ; (iii) systématiser les principales conclusions et discuter des leçons tirées afin que les outils et les méthodes deviennent disponibles aux futurs acteurs et utilisateurs de l'EIS ; (iv) approfondir la compréhension des relations complexes entre les activités liées au développement de projet d'une part et les communautés concernées et leur environnement d'autre part.

Cadre collaboratif : Ce projet de thèse a été réalisé dans le cadre d'une collaboration publique-privée entre l'Institut Tropical Suisse et de Santé Publique (Swiss TPH), à Bâle, et NewFields, une agence internationale de conseil comptant plusieurs années d'expertise dans l’EIS. Les collaborations de NewFields sur plusieurs sites d’EIS menées actuellement pour des clients privés ou publiques ont servi de plate-forme à cette recherche.

Méthode : Les études de terrains de cette thèse de doctorat ont été réalisées dans le cadre d’onze EIS de différents projets de développement industriel dans un pays d’Amérique du Sud et cinq pays africains. Chacune de ces missions a tenu l'opportunité pour le développement, la validation et la consolidation des outils et méthodes en fonction de la phase correspondante dans le processus de l'EIS.

Résultats : Cette recherche a mené au développement d’une trilogie d’EIS comportant trois parties, chacune d’entre elles basée sur une étude de cas. Elle introduit ensuite un panel de méthodologies s’appliquant aux EIS menées dans le cadre écologique et épidémiologique complexe des pays tropicaux. La première partie de ce travail utilise et développe le concept des zones de santé environnementale. Les communautés potentiellement affectées sont stratifiées et on fait appel à différentes méthodes, notamment participatives, dans le but d’obtenir des données sanitaires de base de qualité. L’intégration de ces données dans une matrice d’analyse de risques fournit un classement des impacts sanitaires potentiels, facilitant à terme la sélection des éléments prioritaires lors de la mise au point de stratégie de mitigation. Ces outils ont été développés dans le cadre de l’EIS d’un vaste projet de minerai de fer situé dans une région reculée de la République Démocratique du Congo. Cette recherche, exploitée en tant qu’étude de cas, a abouti à l’identification systématique de nombreux déterminants environnementaux et sanitaires.

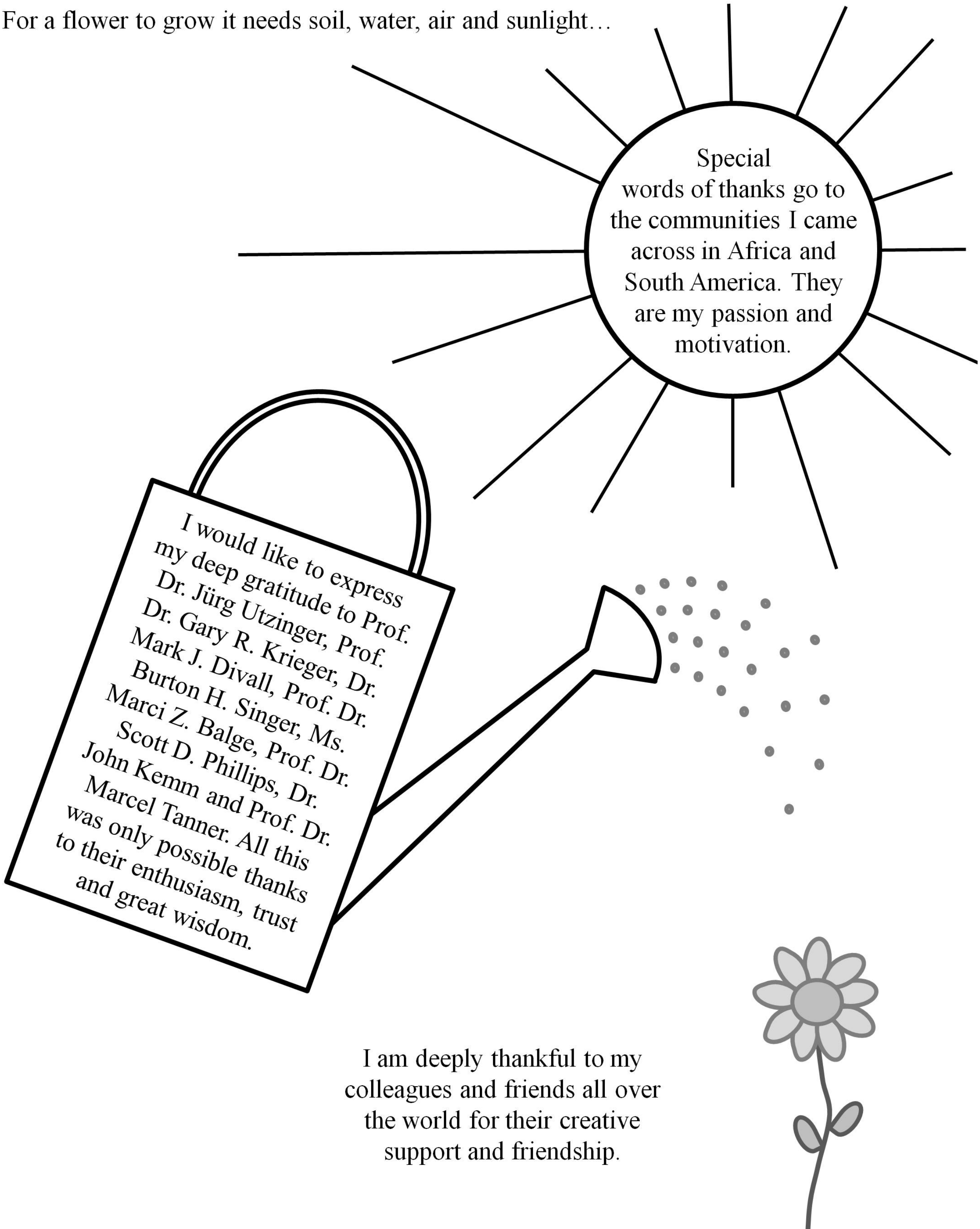
La seconde partie se concentre sur l'importance de la phase de cadrage, illustrée par des exemples spécifiques tirés d’une EIS menée actuellement dans le cadre d’un vaste projet de minerai de fer en République de Guinée. L’intégration de données obtenues par des démarches participatives et complétées par des données statistiques sanitaires locales à une banque de données analytique permet une sélection systématique des effets sanitaires déterminants. L'analyse d’écarts consécutive détermine, d’une part, la nécessité d'une récolte de données sanitaires de base supplémentaire dans la population concernée et facilite, d’autre part, l'identification d’indicateurs et de stratégies de récolte de données potentiels. Cette approche de cadrage plus rigoureuse est actuellement considérée comme un prérequis pour la planification et la mise en œuvre de toute étude sanitaire de base réalisée dans le contexte d'EIS menées dans un cadre complexe, notamment dans les pays en voie de développement.

La dernière partie présente un design modulaire d'étude sanitaire transversale de base spécialement développé pour les EIS de projets industriels mis en place dans les pays en voie de développement. Le cadre modulaire s'adapte facilement aux caractéristiques écologiques et épidémiologiques d'un projet donné. Cette méthodologie se base sur une série d'indicateurs de performance comprenant différents impacts sanitaires ainsi que des déterminants à plusieurs niveaux. Les résultats d'une étude de base menée en République de Guinée, dans la région d'un projet de minerai de fer, illustre l'utilité et la valeur de la méthodologie développée dans ce chapitre. Cette étude démontre que l'évaluation quantitative des impacts sanitaires est une étape indispensable si l'on souhaite profiter pleinement du potentiel de l'EIS. En effet, cette approche permet non seulement de mieux comprendre comment les communautés sont affectées par de nouveaux projets mais aussi d'améliorer le potentiel de prédiction de l'EIS dans des régions où les données démographiques, écologiques, environnementales, épidémiologiques, sanitaires et socioéconomiques sont disperses.

Conclusion : L'approche systématique d'EIS qui a évolué dans le cadre de cette thèse s'aligne parfaitement aux valeurs centrales de l'EIS – utilisation éthique des données probantes, démocratie, équité et développement durable – et apporte une contribution méthodologique remarquable à la science de l'EIS. En outre, cette méthodologie peut facilement être employée dans le cadre d'EIS de projets de développement de grande envergure dans les pays tropicaux, particulièrement depuis que nous avons pu montrer qu'elle s'applique largement à différents types de projets et d'environnements. Cependant, des recherches supplémentaires au niveau des programmes et des politiques de différents secteurs demeurent nécessaires si l'on souhaite exploiter entièrement le potentiel de l'EIS dans les pays en voie de développement. Dans le même temps, nous proposons que l'Organisation Mondiale de la Santé et la communauté de l'EIS dans son ensemble doive fournir tous les efforts possibles dans le développement et le renforcement du domaine de l'EIS, au niveau académique et au niveau gouvernemental des pays en voie de développement.

Acknowledgements

For a flower to grow it needs soil, water, air and sunlight…



I also want to acknowledge funding from the Dissertationenfonds of the University of Basel for the printing of the present thesis.

My sincerest thanks are addressed to Nurten Kaya-Winkler, Marianne Winkler, Federico Winkler, Matteo Winkler and Dr. Jürg Düblin. There are no words that could describe my gratitude to them for having supported and encouraged me with my studies and special interest in Africa over all these years.

Table of contents

List of figures

List of tables

List of abbreviations

AIDS	Acquired Immune Deficiency Syndrome
ART	Anti-Retroviral Treatment
BHS	Baseline Health Survey
BMC	Borgakim Medical Centre
BS	Baseline Study
CDC	Centres for Disease Control and Prevention
CHMP	Community Health Management Plan
CIA	Central Intelligence Agency
CO_2	Carbon Dioxide
CSDH	Commission on Social Determinants of Health
DALY	Disability Adjusted Life Year
DHS	Demographic and Health Survey
DNS	Direction Nationale de la Statistique
DRC	Democratic Republic of the Congo
ECHP	European Centre for Health Policy
EHA	Environmental Health Area
EHIA	Environmental Health Impact Assessment
EIA	Environmental Impact Assessment
EnvM	Environmental Monitoring
EPFI	Equator Principles Financial Institutions
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GAELF	Global Alliance to Eliminate Lymphatic Filariasis
GBD	Global Burden of Disease
GDHS	Guinean Demographic and Health Survey
GDP	Gross Domestic Product
GPN	Good Practice Notes
HAT	Human African Trypanosomiasis
HFS	Health Facility Statistics
HIA	Health Impact Assessment
HIV	Human Immunodeficiency Virus
HPP	Healthy Public Policy

HRA	Health Risk Assessment
HSE	Health and Safety Executive
HSS	Health System Strengthening
IA	Impact Assessment
IAIA	International Association for Impact Assessment
ICMM	International Council on Minerals and Metals
IEA	International Energy Agency
IEC	Information, Education and Communication
IFC	International Finance Corporation
IFI	International Financial Institutions
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPIECA	International Petroleum Industry Environmental Conservation Association
IPT_p	Intermittent Preventive Treatment during Pregnancy
ITN	Insecticide-Treated Net
KABP	Knowledge, Attitude, Behaviour and Practice
KAP	Knowledge, Attitude, Practice
KII	Key Informant Interview
KPI	Key Performance Indicator
Lao PDR	Lao People's Democratic Republic
LLC	Limited Liability Company
M&E	Monitoring and Evaluation
MAP	Malaria Atlas Project
MDG	Millennium Development Goal
MGL	Moto Goldmines Limited
MHPH	Ministry of Health and Public Hygiene
MICS	Multiple Indicator Cluster Surveys
MoH	Ministry of Health
ND	National Data
NEPA	National Environmental Policy Act
NGO	Non-Governmental Organization
NSCS	National Survey on the Nutritional Status and Key Indicators of Child Survival
OFS	Optimised Feasibility Study

OKIMO	Office des Mines d'Or de Kilo-Moto
P.R. China	People's Republic of China
PAC	Potentially Affected Community
PhD	Doctor of Philosophy
PPP	Public-Private Partnership
PRB	Population Reference Bureau
RADS	Resettlement and Development Solutions
RBM	Roll Back Malaria Partnership
RDT	Rapid Diagnostic Test
RPF	Resettlement Policy Framework
SIA	Social Impact Assessment
SNIS	Service National d'Information Sanitaire
STH	Soil-Transmitted Helminth
STI	Sexually Transmitted Infection
Swiss TPH	Swiss Tropical and Public Health Institute
ToR	Terms of Reference
UK	United Kingdom
UN	United Nations
UNAIDS	United Nations Programme on HIV/AIDS
UNICEF	United Nations Children's Fund
USA	United States of America
USAID	United States Agency for International Development
USEIA	U.S. Energy Information Administration
VCT	Voluntary Counselling and Testing
WHO	World Health Organization
WPRO	WHO Western Pacific Regional Office
WTO	World Trade Organization

1. Introduction

This PhD thesis aims at providing a set of well-defined methodologies for various steps within the health impact assessment (HIA) process that are primarily designed for industrial development projects in a tropical country context. Moreover, ways for the further promotion of HIA in developing country settings are explored. This introduction will first give insights into the origin of HIA as the last addition in the suite of impact assessments (IA), then lead through the mainstays of the HIA concept, followed by an introduction to the HIA process. Subsequently, a global view on HIA practice is given, placing particular emphasis on industrial projects in developing country settings. Finally, identified research needs, objectives, study sites and the overall framework of the PhD thesis are outlined.

1.1. The origin of HIA

The notion of IA emerged in the 1960s when environmental impact assessment (EIA) started to become a common feature of the rational decision-making process in the United States of America (USA). This development was closely linked to the enactment of a revolutionary piece of legislation, namely the 'National Environmental Policy Act' (NEPA), instigated in 1969 (NEPA, 1970). The NEPA established, for the first time, national policies and goals for the protection of the environment, as per the following declaration:

> *"The purposes of this Act are: To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality."*

The NEPA became the first comprehensive legal basis for EIA worldwide and emphasised at the same time the close interconnectivity between physical environment and human health. Consequently, the identification, evaluation and mitigation of health impacts related to public and private sector activities became an integral part of the EIA process (Canter, 1996; Marriott, 1997). Today, more than 500 federal programmes undergo an EIA in the USA every year, and thousands more are evaluated using a similar but less-detailed process termed "environmental assessment" (Bhatia and Wernham, 2008).

In parallel to the development and spread of EIA, the concept of healthy public policy (HPP) emerged, which claimed the evaluation of health effects of public policies and decisions. Health was seen as the product of the physical environment and behaviour patterns and the role of HPP is to assure that individuals and organisations can choose between health-promoting and health-damaging policies (Milio, 1981). As response to growing expectations for a new public health movement around the world, the World Health Organization (WHO) organised the first International Conference on Health Promotion in Ottawa in 1986 (WHO, 1986). With this formal act, it was acknowledged that virtually all public policies impact on health and the role of health promotion was to enable people to increase control over, and to improve, their health.

Over time the field of IA further diversified and new braches emerged such as social impact assessment (SIA) in the 1970s or environmental health impact assessment (EHIA) as a component of EIA dealing specifically with human health (Fehr, 1999). However, with the increasing claim for HPP, dealing with health in the context of EIA appeared to be unsatisfactory in the long term. Within EIA, health was invariably conceptualised narrowly rather than comprehensively and the ensuing recommendations tended to focus on action required by the health sector, usually overlooking options to integrate health into development policies and into programme/project design and operation (Bos, 2006). Consequently, it was only a question of time until a separate form of IA with a specific focus on human health arose – HIA (Scott-Samuel, 1996).

1.2. The concept of HIA

1.2.1. Definitions and core values

Various definitions of HIA have been proposed over the past 15 years (Mindell et al., 2008). For example, Ratner et al. (1997) defined HIA as *"any combination of procedures or methods by which a proposed policy or programme may be judged as to the effect(s) it may have on the health of a population."* Two years later, at a consensus conference in Gothenburg, the WHO's European Centre for Health Policy (ECHP) added *"and the distribution of those effects within the population"* (WHO/ECHP, 1999). A more recent definition given by the international best practice principles for HIA reads as follows (Quigley et al., 2006): *"Health impact assessment may be defined as a combination of procedures, methods and tools that systematically judges the potential, and sometimes unintended, effects of a policy, plan,* *programme or project on the health of a population and the distribution of those effects within the population. HIA identifies appropriate actions to manage those effects."* A contemporary definition by the WHO (2011) is as follows: *"a practical approach used to judge the potential health effects of a policy, programme or project on a population, particularly on vulnerable or disadvantaged groups."*

In summary, HIA is both a prospective approach looking at potential effects, and an equity-focused one looking at distributional impacts (Scott-Samuel, 2005). Furthermore, HIA is concerned with the effect of development on health, while the development activity *per se* may or may not have an explicit objective to improve health. Consequently, a considerable number of projects, programmes and policies that apply HIA are initiated outside the health sector (WHO, 2001; Cole et al., 2004; Salay and Lincoln, 2008).

With the goal to avoid that HIA runs the danger of being an artificial process, divorced from the reality of the policy environment in which it is being implemented, four core values were selected that are of particular importance for HIA (WHO/ECHP, 1999; Kemm and Parry, 2004; Quigley et al., 2006):

- **democracy**, emphasising the right of people to participate in a transparent process for the articulation, implementation and evaluation of policies that affect their life, both directly and through the elected political decision-makers;
- **equity**, emphasising that HIA is not only interested in the aggregate impact of the assessed policy on the health of a population, but also on the distribution of the impact within the population, in terms of gender, age, ethnic background and socio-economic status;
- **sustainable development**, emphasising that both short-term and long-term as well as more and less direct impacts are taken into consideration; and
- **ethical use of evidence**, emphasising that the use of quantitative and qualitative evidence has to be rigorous, and based on different scientific disciplines and methodologies to get as comprehensive assessments as possible of the expected impacts.

1.2.2. The purpose and function of HIA

The purpose of HIA is to influence decision-making in order to maximise the health benefit of a proposal and minimise the harm (Scott-Samuel, 1998; Joffe and Mindell, 2005; Veerman et al., 2005). In order to realise its important function to contribute to healthy projects and healthy public policy, HIA applies a set of key strategies that reflect the afore mentioned core values. First, HIA involves and engages health experts, project proponents, other key players and the community affected by the proposal, and facilitates broad public participation in decision-making (André et al., 2006). Second, it uses the best available evidence to assess the likely effect of a specific policy in a specific situation (Kemm, 2001; Mindell et al., 2004). Third, HIA raises the awareness among decision-makers that their actions affect health and thereby ensuring that they always consider health consequences in their deliberations (Kemm et al., 2004; Brownson et al., 2006). Finally, HIA serves as a tool to interlink public and private organisations from the health and other sectors with the aim to promote intersectoral collaboration for health promotion (Krieger et al., 2003; Smith et al., 2006; Sicilia and Purroy, 2008).

HIA can take place at any level, from local or regional to national or supranational (Wismar, 2005; Davenport et al., 2006). Furthermore, proposals subject to HIA can originate and be developed within the private, public or voluntary sector (Joffe and Mindell, 2005). Consequently, HIA are typically commissioned by (i) local, regional and national authorities; (ii) national and international development banks; and (iii) the private sector. Ideally, HIA take place at an early stage in the development of a policy or project to permit constructive modifications to be carried out before its implementation, but late enough for a clear idea to have been formed regarding the nature and content of the proposal (Scott-Samuel, 1998). There is still some debate whether concurrent and retrospective assessments of projects, programmes and policies should be considered HIA (Hübel and Hedin, 2003; Kemm, 2003; Krieger et al., 2003; Joffe and Mindell, 2005; Dannenberg et al., 2006). It is, however, important to recognise that the knowledge-base for prospective studies essentially derives from existing retrospective assessments of the health impacts of public policies, programmes and projects (Scott-Samuel, 1998; Harris-Roxas and Harris, 2007). Moreover, when conducting HIA in a highly dynamic context (e.g. an industrial project in the developing world) the nature and severity of potential health impacts can be influenced as the proposal progresses and does thus require monitoring and adaption of mitigation measures, which is referred to as concurrent HIA.

1.2.3. The concept of health used in HIA

In general, the concept of health used in HIA is broader than merely the absence of disease or infirmity (Scott-Samuel, 2005). Instead, it encompasses all aspects of physical, mental, and social health, considering positive health as well as the absence of illness (Joffe and Mindell, 2005). Consequently, the determinants of health considered in HIA include not only exposure to disease, but also the factors that might affect the presence/risk of exposure, such as (i) biological factors (e.g. age, gender and genetics); (ii) psychosocial environment (e.g. family structure, community networks, cultural health practices, social exclusion and stigmatisation); (iii) personal behaviour and lifestyle (e.g. diet, substance abuse and physical activity); (iv) physical environment (e.g. water, housing, disease vectors and environmental pollution); (v) socio-economics (e.g. employment and education); (vi) public services (e.g. quality of, and access to, health and other social services); (vii) public policy (e.g. public health initiatives, security, economic development and public transport) (Lock, 2000; Joffe and Mindell, 2002). For example, an HIA of a road construction in Africa might consider the risk of air and noise pollution, effects on transmission of disease and risk of injury, as well as the benefits of being able to gain better access to health care, education and work.

1.2.4. The evidence-base for HIA

In view of the many factors considered in HIA, the evidence-base used for the assessment becomes of crucial importance (Mindell et al., 2004). Parry and Stevens (2001) noted: *"Prediction of the health impacts of any intervention depends on a synthesis of all available evidence to produce an estimate of the likely effect and the application of this estimate to the affected population."* In other words, a sound evidence-base is essential for the long-term reputation of HIA as it is directly linked to the quality of its predictions (Joffe and Mindell, 2002). Key tools for the enhancement of the evidence-base for HIA are: (i) literature reviews; (ii) stakeholder consultation; and (iii) systematic collection of information on health determinants and outcomes in potentially affected communities (Parry and Stevens, 2001; Joffe and Mindell, 2005). Literature reviews for HIA usually require synthesis of evidence from epidemiological, toxicological and sociological studies, using a wide range of methodologies, as well as studies from different disciplines and topic areas, using both quantitative and qualitative methods (Mindell et al., 2004; O'Connell and Hurley, 2009). Stakeholder involvement is an essential feature of HIA, not only as part of the evidence gathering and validating process but also for building interest in a project and improve the chances of the health recommendations being seriously considered (Lerer, 1999; Birley, 2003; Mindell et al., 2004). The systematic collection of information on health determinants and outcomes in potentially affected communities, using a combination of quantitative and qualitative methods, becomes a necessity in settings where baseline health and socio-economic data are lacking (Singer and Castro, 2007; Krieger et al., 2008; Fewtrell and Kay, 2008a). Such baseline health data are also required for continuous monitoring of health impacts of a proposal and, finally for evaluating the performance of HIA *per se* (Krieger et al., 2003; Quigley and Taylor, 2003; Erlanger et al., 2008a).

1.3. The HIA process

The methods and procedures for performing HIA have developed over the last two decades and a variety of national and international guidelines have been published by the public and private sector (see section 1.4). Although each guideline is adapted to the characteristic/requirements of their country or institution, the general framework used for HIA remained the same. The common process that is followed is shown in the context of HIA of a project in Figure 1.1. Each step is outlined in more detail in the following sections based on guidance developed by Joffe and Mindell (2005) and the International Finance Corporation (IFC) (2009).

1.3.1. Screening

The first stage is screening. Its main purpose is to filter out proposals that: (i) do not require a HIA because the anticipated impact on health is minimal; or (ii) there is no option to influence decisions regarding the potential health impacts of the planned proposal. Ideally, screening is done using a systematic process that is based on a set of pre-set criteria against which proposals are assessed.

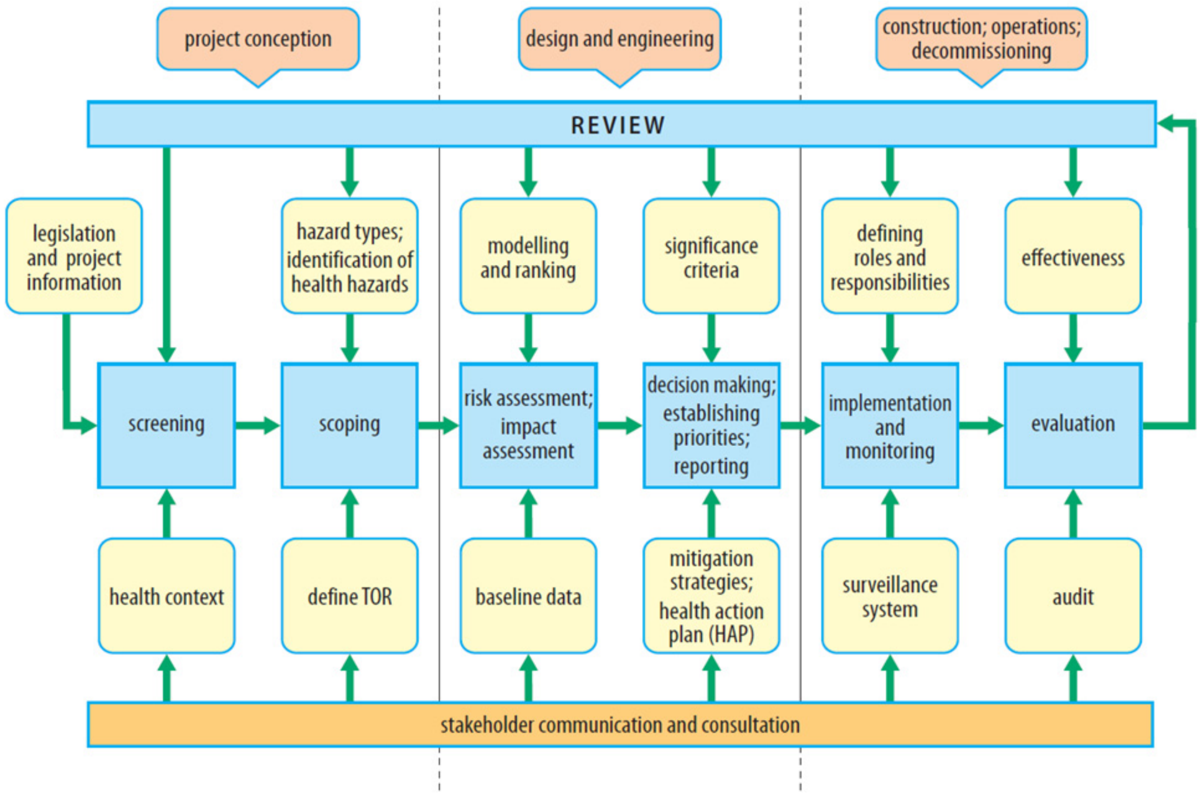


Figure 1.1: The HIA process (Source: IPIECA, 2005; IFC, 2009).

1.3.2. Scoping

In case the requirement for HIA is given at the screening stage, the boundaries of the HIA are set at the second stage, which is termed scoping. The objectives of the scoping process are (i) to decide which elements or aspects of a proposal are to be assessed; (ii) to identify the range of potential project-related health impacts; and (iii) to define stakeholders for the HIA and the nature of their involvement. The populations potentially affected by a project, programme or policy are defined, which includes the identification of vulnerable, marginalised or disadvantaged groups. The scoping stage is also the point when the timing and geographical boundaries are set. All these factors are directly related to the required depth of appraisal.

In general there are two poles of complexity of the assessment: (i) rapid HIA which use evidence that is already available or easily accessible and are suitable for less complex proposals; and (ii) comprehensive HIA. The latter generally involve the collection of new data and should be considered for large, complex projects, particularly if resettlement or relocation of existing communities is involved or if the project is likely to trigger considerable in-migration. There is no clear dividing line to indicate the depth of appraisal a project, programme or policy needs. A possible rationale for the selection of the required depth of appraisal is given by the HIA guidelines of the IFC as shown in Figure 1.2.

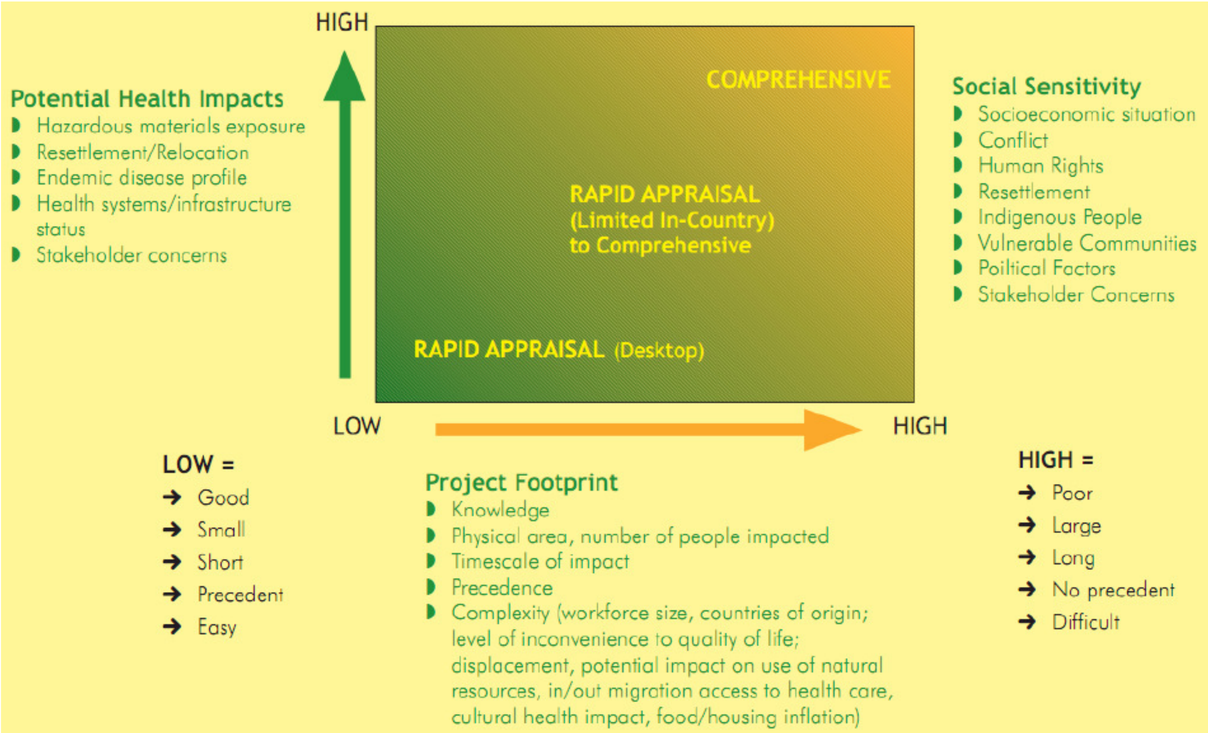


Figure 1.2: Qualitative decision guidance for selecting the required depth of HIA (Source: IFC, 2009).

Importantly, the scoping stage also includes the assessment of the available evidence-base and identifies existing data gaps (Joffe and Mindell, 2002; Cole et al., 2005; Thamlikitkul, 2006; IFC, 2009). Concluding, scoping is a central stage of HIA as it provides the blueprint for the entire assessment and defines the terms of reference (ToR) for all subsequent phases. In this regard, input of key stakeholders and the relevant host-country health authorities is critical, so that the HIA adequately addresses a realistic range of health concerns.

1.3.3. Risk assessment

The risk assessment stage is initiated once the required evidence-base for the HIA has been completed. This third stage of the HIA involves the systematic analysis of the consequences, severity, likelihood and nature (i.e. direct, indirect or cumulative) of anticipated impacts. Importantly, differences in the profile of the potentially affected population(s) are considered and separate impact appraisals may be indicated due to particular vulnerabilities or susceptibilities to specific impacts. Similarly, the cycles of a proposal are incorporated into the appraisal. For the analysis different methods, such as stakeholder workshops and modelling, can be used separately or in combination.

1.3.4. Appraisal and mitigation

The fourth stage of the HIA process involves definition of mitigation measures and recommendations. Mitigation is a systematic process that considers options to avoid, reduce, remedy, or even compensate for potentially negative impacts. Nonetheless it is also crucial to identify and highlight positive impacts or health opportunities related to the planned proposal at this stage (Birley, 2003). Participation of decision-makers and other key stakeholders in the appraisal and mitigation phase (e.g. through the participation of a steering group or stakeholder workshops) increases the likelihood of the findings of the HIA being considered relevant to the decision-making process – a prerequisite for acceptance of recommendations (Joffe and Mindell, 2005; Wright et al., 2005). In this regard, transparency in the applied methods, evidence-base and decisions taken is fundamental, allowing outside experts and stakeholders to scrutinise and comment upon HIA findings (Harris et al., 2007; O'Connell and Hurley, 2009).

1.3.5. Implementation and monitoring

After the formulation of appropriate mitigation strategies, it is necessary to define clear roles and responsibilities for the implementation of selected interventions, including allocation of required resources. This is not always straightforward and the importance of stakeholder engagement in HIA is re-emphasised in this regard. Monitoring is necessary to ensure that the mitigation progress is satisfactory (Adrien et al., 2008). It is imprudent to assume that because a recommendation has been accepted it will be implemented (Joffe and Mindell, 2005). Also changes in political or corporate governance may further alter decisions. At the same time, a well-designed monitoring system might be able to determine unanticipated impacts and thus provide an early-warning system for adverse developments. However, whether and to what extent implementation and monitoring are part of a given HIA depends on the nature and context of the proposal. For example, in the frame of a concurrent HIA of a large-scale development project in the tropics, this fifth phase plays an important role as the nature and severity of potential health impacts may change over time and thus adaption of the implemented mitigation measures is required.

1.3.6. Evaluation

During the evaluation of HIA issues such as whether predictions and recommendations made by the HIA turned out to be accurate and whether the implementation of the recommendations led to improvements in health outcomes are addressed. For this purpose different indicators for the process-, impact- and outcome evaluation have been proposed (Quigley and Taylor, 2004). Without evaluation, the effectiveness of HIA cannot be demonstrated and its credibility is weakened. Hence, evaluation is a key step in the overall HIA process and an important source of learning (Quigley and Taylor, 2003).

1.4. A global view on HIA practice

After it had been acknowledged in the 1980s and 1990s that virtually all public policies impact on health, consideration of health impacts has been encouraged across the world (Milio, 1981; WHO, 1986; Scott-Samuel, 1998; Lock, 2000; Kemm, 2001). In 1992, the first new-style HIA was carried out on the proposed second runway at Manchester airport in the United Kingdom (UK) (Scott-Samuel, 2005). Two years later, in 1994, the Ministry of Health (MoH) in British Columbia, Canada, published the first toolkit on how to carry out rapid prospective HIA (Population Health Resource Branch, 1995). Later in the 1990s, similar guidance was produced in Australia (Ewan et al., 1994), the UK (Department of Health, 1995), New Zealand (Public Health Commission, 1995) and Canada (Davies, 1995).

Nowadays, HIA is common practice in many European countries, such as the Netherlands (Lebret and Staatsen, 2002), the UK (Quigley and Taylor, 2003), Finland (Ståhl et al., 2006), Germany (Fehr et al., 2003) and Sweden (Finer et al., 2005). HIA has also been institutionalised in Australia (Mahoney, 2007; Spickett et al., 2011; Harris and Spickett, 2011), Canada (Health Canada, 1999), the USA (Cole et al., 2004; Dannenberg et al., 2006), New Zealand (Mahoney and Morgan, 2001) and Thailand (Phoolcharoen et al., 2003). Moreover, the European Union and international organisations and donors have integrated selected environmental and social aspects of health into the screening, scoping, risk assessment, decision-making and monitoring of projects, programmes and policies, with HIA playing an important role in this regard (Hübel and Hedin, 2003; Mekel et al., 2004; Wismar, 2005). In 2006, the Finnish government made HIA and 'Health for all Policies' central strands of its 2006 presidency of the European Union (Ståhl et al., 2006).

In the African Region, the assessment of health impacts has been promoted as part of EIA and SIA by major development agencies for over two decades and more recently also by the extractive industry (Birley, 2005; International Petroleum Industry Environmental Conservation Association (IPIECA), 2005; Vohra, 2007; International Council on Mining and Metals (ICMM), 2010). Moreover, a large consortium of international development banks, known as the Equator Principles Financial Institutions (EPFI), incorporated IFC's performance standards on social and environmental sustainability as part of loan covenants (EPFI, 2006; IFC, 2006). This created a clear enforcement mechanism for socially responsible conduct and sound environmental practices in relation to project finance initiatives.

The situation in other tropical regions of the world presents similar to that of the African Region. Only Thailand, India and Lao People's Democratic Republic (Lao PDR) have a regulatory requirement for performance of HIA and capacity building efforts are underway in other countries such as Vietnam, Korea, Cambodia and the People's Republic of China (P.R. China) (Phoolcharoen et al., 2003; Vohra, 2007; WHO Representative Office in Vietnam, 2009; Huang, 2011; Harris-Roxas, 2011; Kang et al., 2011; Wu et al., 2011).

Erlanger et al. (2008b) addressed the question: *"Where in the world have HIA been carried out?"* with a systematic search of HIA-related publications in the peer-reviewed literature. For the time between 1976 and May 2007, 237 papers with an explicit focus on HIA were identified. Most of these papers (n = 185, 78%) were published in the new millennium, which reveals the recent and exponential growth of the HIA literature. Furthermore, the systematic review showed that most of HIA-related work published in academic journals focused on industrialised country settings. Among the 237 identified HIA-related publications, 176 (74%) could be assigned to one or more countries. This information was transferred onto a world map as shown in Figure 1.3.

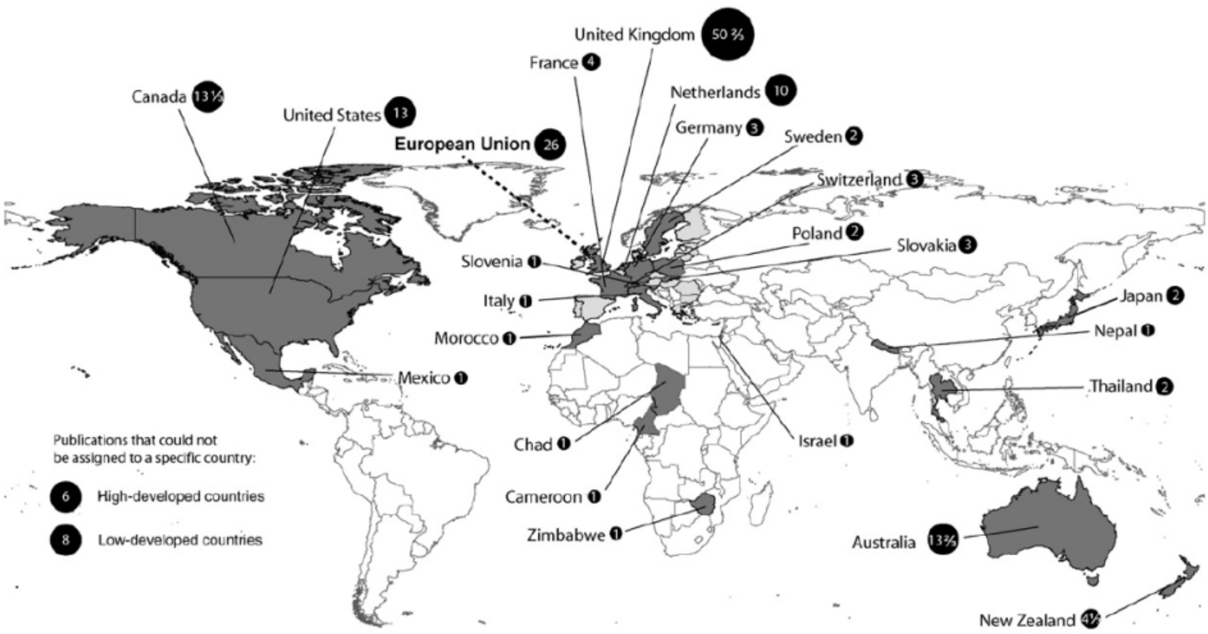


Figure 1.3: Number of publications in the peer-reviewed literature focussing either on high-developed countries, or low- and middle-developed countries. Of note, fractions indicate that the focus in some publications was on multiple countries and hence the publication count was divided by the number of countries involved (Source: Erlanger et al., 2008b).

Against this background it appears that there is a clear division line between HIA practice in developed and developing countries. While guidelines and tools for implementing HIA have been developed and used in industrialised countries (WHO, 2011), their use in the developing world appears to be limited. This is partially explained by contextual and legislative concerns as most low-income countries lack legislations for institutionalising HIA (Caussy et al., 2003). Additionally, the paucity of readily available HIA methodologies was identified as a restriction for the promotion of HIA in the developing world (Lerer, 1999; Parry and Stevens, 2001; Putters, 2005).

1.5. Industrial developments projects in the developing world

Industrialisation is the process of social and economic change that transforms a human group from an agrarian society into an industrial one. It is a part of a wider modernisation process, where social change and economic development are closely related with technological innovation, particularly with the development of large-scale energy and metallurgy production (O'Sullivan and Sheffrin, 2002). Industrialisation began with the industrial revolution in the 18th century in the UK, then spread throughout Europe, North America and eventually the rest of the world. The introduction of steam power, wider utilisation of water wheels and powered machinery led to a dramatic increase in production capacity and led to the creation of factories (Meier and Rauch, 2000). The factory system was largely responsible for the rise of the modern cities, as large numbers of workers migrated into the cities in search of employment in the factories. Overall, the industrial revolution led to a population increase, but the chances of surviving childhood did not improve throughout the industrial revolution (Buer, 1926; Bar and Leukhina, 2010). As there was still limited opportunity for education, children were expected to work. Many children and adolescents were physically handicapped, or even died due to injury, intoxication, respiratory diseases and other causes (Humphries, 2010). Living conditions varied from the splendour of the homes of the factory owners to the very small houses in cramped streets with shared toilet facilities and open sewing systems, favouring the spread of cholera, typhoid and other water- and waste related diseases (Engels, 1892). Until about 1750, life expectancy in France was approximately 35 years, and only slightly higher in the UK (Fogel, 2004).

Two and a half centuries later we know that the prosperity of the developed world is built on the age of industrialisation, including the rather dark chapter of industrial revolution. Still today, industrial revolution continues, at a smaller scale though. The following is a recent extract of the *Queenstown Daily*, the national newspaper of Zambawi, a fictive republic in sub-Saharan Africa (Neate, 2000):

> *"Two years after the fall of President Adini and his corrupt regime, things are developing very fast in our country as exemplified by the construction of a new goldmine in the region of Mutengwazi village. Only 20 months after the joint-venture agreement between the government and 'GoldRush International' was signed, live in the future mining area has changed completely. As an initial step, all the people from Mutengwazi were resettled to a new area down the road to Queenstown. This was widely accepted due to fair compensations and because the project was seen as great opportunity. Soon after, an elected amount of people was employed by the project and paid exorbitant wages compared to the average income level in the region. The money helped villagers to improve the living standard of their families, and at the same time they invested money in the creation of various small-scale business activities, including shops, small bars and nightclubs. In addition, with the presence of the project the road infrastructure was significantly improved, which led to a strong increase in traffic. The*

project is using the roads for its all-terrain vehicles, mobile machinery and heavy trucks that transport construction material and the local people enjoy the gained mobility with motorbikes, cars and pick-ups. The message of jobs and many other opportunities spread quickly across the country and new people, including mechanics, graduate students, businessmen and prostitutes, arrive every day via the new access roads, hoping for accommodation and a job to earn a living. The multilayered developments in the former region of Mutengwazi village are truly fascinating and it will be interesting to see how the mining company and the local authorities manage the various challenges that have arisen with this new venture; or shall we say adventure?"

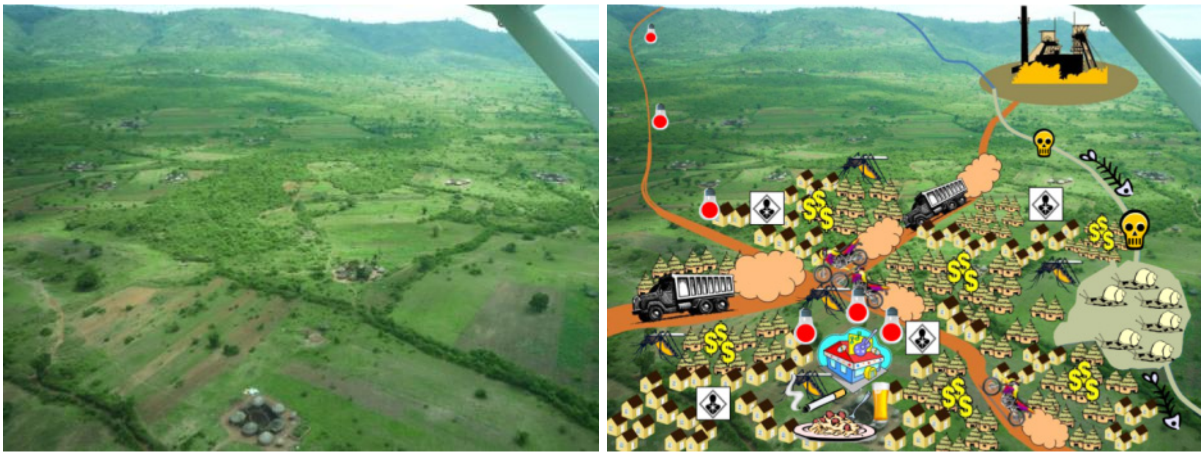


Figure 1.4: The change from an agrarian society in rural Africa into an industrial one – a worst case scenario (Source: Winkler, 2009).

The industrial revolution in the 18th century and today's small-scale industrial revolutions in low-and middle-income countries have many commonalities. Both have proven enormous potential to promote social-wellbeing and economic development at a small- and large-scale (Sachs, 2005; Moyo, 2009). Furthermore, both trigger similar mechanisms such as exploitation of natural resources, involuntary resettlement of communities, migration of populations, and altered socio-economic structures. Consequently they also share the risk to cause: (i) social inequalities and conflicts, (ii) environmental degradation, and (iii) an increase in the burden of disease. The latter is of particular concern in tropical and sub-tropical countries as these are most afflicted by the HIV/AIDS and tuberculosis pandemic (Corbett et al., 2003; Asamoah-Odei et al., 2004; Oster, 2005). Moreover, the climate favours the transmission of vector-borne diseases (Guerra et al., 2006; Hay et al., 2009) and water-borne diseases (Lopez et al., 2006; Steinmann et al., 2006). Indeed, 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) and water-resource development and management (Lerer and Scudder, 1999; Fearnside, 2005; Krieger et al., 2008; Fewtrell and Kay, 2008b; Kittinger et al., 2009; Yewhalaw et al., 2009). Expressed differently, in words of Mindell et al. (2010): *"the comparatively high rates of morbidity and mortality experienced in middle- and low-income countries can only partly be addressed by improving health-care provision, so the need for HIA is even greater in these countries than in the developed world."*

1.6. Identified research needs

In view of current predictions of the extractive industry and water resource developments in the developing world, there is a pressing need to institutionalise HIA in developing countries (Erlanger et al., 2008b). The lack of well-defined HIA methodologies that are designed for the purpose of a typical tropical country context is an important constraint to comply with this request (Parry and Stevens, 2001; Putters, 2005). Hence, the development and rigorous validation of new methodologies for complex eco-epidemiological settings typically encountered in the humid tropics is needed. Tools for the structured analysis of complex baseline health data and robust techniques for the IA process to facilitate predictions about future health impacts are essential (Krieger et al., 2003; Quigley and Taylor, 2003; Singer and Castro, 2007; Fewtrell and Kay, 2008a). In turn, such tools will create the missing basis for the continued assessment of the scope and limits of HIA in the developing world, which is crucial for further advancing HIA and to make it a broadly applicable tool and process for mitigating negative health effects and maximise positive health effects of project, programmes and policies (Birley, 2003; Quigley and Taylor, 2003; Kemm, 2005; Veerman et al., 2007).

1.7. Goals and objectives

The overarching goal of this PhD thesis was to develop and further advance HIA tools and methods that are designed for the purpose of complex eco-epidemiological settings in low- and middle-income countries, to validate these tools and methods within the frame of HIA of industrial development projects in tropical country contexts and to deepen the understanding of linkages of project-related activities with affected communities.

In order to achieve these goals, the following specific objectives were pursued:

1.) to develop and advance HIA tools and methods that are aligned to manage the many factors of complex epidemiological settings in the humid tropics, with an emphasis on the scoping, impact assessment and mitigation process;
2.) to develop a cross-sectional baseline health survey study design for HIA of industrial development projects in tropical country contexts that can be readily adapted to the prevailing eco-epidemiological characteristics of a given project setting;
3.) to validate the developed HIA tools and methods within the frame of industrial development projects (extractive industry or water-resource developments) in developing country contexts;
4.) to systematise key findings and discuss lessons learned so that the tools and methods become available to HIA practitioners; and
5.) to deepen the understanding of the complex linkages of project-related activities with affected communities and their environment.

1.8. Collaborative framework and study sites of the PhD thesis

1.8.1. Public-private partnership

This PhD thesis in Epidemiology at the University of Basel was carried out within the frame of an existing public-private partnership (PPP) between the Swiss Tropical and Public Health Institute (Swiss TPH, Basel, Switzerland) and NewFields LLC (Denver, USA and Pretoria, South Africa). NewFields has a huge body of experience and expertise in HIA in the extractive industry (e.g. oil/gas and mining) and of water resource developments (e.g. large dams). Collaboration in selected HIA assignments for private and public clients of NewFields served as platforms for the present research project.

1.8.2. Study sites

The study area of this PhD thesis was roughly defined as developing country settings. Due to the particular condition of the PPP – which was depending on short- and long-term assignments of NewFields – details of the study areas could not be defined upfront. In the end, this PhD thesis entailed field work in South America and sub-Saharan Africa in the frame of 11 HIA for different industrial development projects (9 mining projects, 1 biofuel project, 1 deep-water port development), each of which held the opportunity for further validation and consolidation of the developed methodologies according to the respective stage of the HIA process. The location of the different projects is shown in Figure 1.5 and brief project descriptions are provided in the Appendix (section 7).

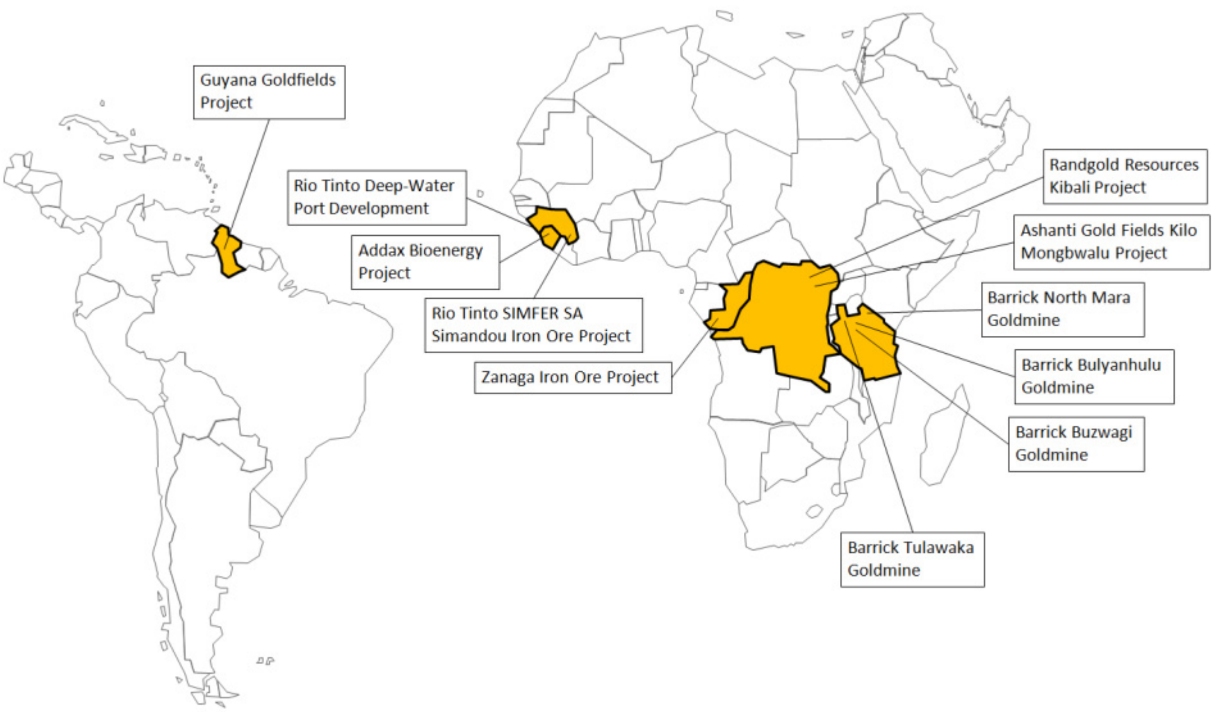


Figure 1.5: Location of projects that served as study sites for the current PhD thesis.

1.9. References

Adrien MH, Bamberger M, Conner RF, Djokovic-Papic D, Hancioglu A, Jankovic V, Jobin D, Vestman OK, Kusek JZ, Mackay K, McWhinney D, Parker D, Petrovic O, Pron N, Segone M, Rist R, Salah MA, Vadnais D, Vasic V, et al. (2008). *Bridging the gap: the role of monitoring and evaluation in evidence-based policy making*. New York, U.S.: The United Nations Children's Fund.

André P, Enserink B, Connor D, Croal P (2006). *Public participation international best practice principles. Special Publication Series No. 4*. Fargo, U.S.: International Association for Impact Assessment.

Asamoah-Odei E, Calleja JMG, Boerma JT (2004). *HIV prevalence and trends in sub-Saharan Africa: no decline and large subregional differences*. Lancet 364: 35-40.

Bar M, Leukhina O (2010). *Demographic transition and industrial revolution: a macroeconomic investigation*. Review of Economic Dynamics 13: 424-451.

Bhatia R, Wernham A (2008). *Integrating human health into environmental impact assessment: an unrealized opportunity for environmental health and justice*. Environmental Health Perspectives 116: 991-1000.

Birley M (2003). *Health impact assessment, integration and critical appraisal*. Impact Assessment and Project Appraisal 21: 313-321.

Birley MH (2005). *Health impact assessment in multinationals: a case study of the Royal Dutch/Shell Group*. Environmental Impact Assessment Review 25: 702-713.

Bos R (2006). *Health impact assessment and health promotion*. Bulletin of the World Health Organization 84: 914-915.

Brownson RC, Royer C, Ewing R, McBride TD (2006). *Researchers and policymakers: travelers in parallel universes*. American Journal of Preventive Medicine 30: 164-172.

Buer MC (1926). *Wealth and population in the early days of the industrial revolution*. London, U.K.: George Routledge & Son.

Canter LW (1996). *Environmental impact assessment*. New York, U.S.: The McGraw-Hill Companies.

Caussy D, Kumar P, Sein UT (2003). *Health impact assessment needs in south-east Asian countries*. Bulletin of the World Health Organization 81: 439-443.

Cole BL, Shimkhada R, Fielding JE, Kominski G, Morgenstern H (2005). *Methodologies for realizing the potential of health impact assessment*. American Journal of Preventive Medicine 28: 382-389.

Cole BL, Wilhelm M, Long PV, Fielding JE, Kominski G, Morgenstern H (2004). *Prospects for health impact assessment in the United States: new and improved environmental impact assessment or something different?* Journal of Health Politics Policy and Law 29: 1153-1186.

Corbett EL, Watt CJ, Walker N, Maher D, Williams BG, Raviglione MC, Dye C (2003). *The growing burden of tuberculosis: global trends and interactions with the HIV epidemic*. Archives of Internal Medicine 163: 1009-1021.

Dannenberg AL, Bhatia R, Cole BL, Dora C, Fielding JE, Kraft K, McClymont-Peace D, Mindell J, Onyekere C, Roberts JA, Ross CL, Rutt CD, Scott-Samuel A, Tilson HH (2006). *Growing the field of health impact assessment in the United States: an agenda for research and practice*. American Journal of Public Health 96: 262-270.

Davenport C, Mathers J, Parry J (2006). *Use of health impact assessment in incorporating health considerations in decision making*. Journal of Epidemiology and Community Health 60: 196-201.

Davies K (1995). *National health guide for environmental assessment*. Ottawa, Canada: Ministry of Health.

Department of Health (1995). *Policy appraisal and health*. London, U.K.: Department of Health.

Engels F (1892). *The coditions of the working-class in England in 1844*. London, U.K.: Swan Sonnenschein & Co.

EPFI (2006). *The Equator Pronciples*. London, U.K.: The Equator Principles Association [http://www.equator-principles.com; accessed: 9 May 2011].

Erlanger TE, Krieger GR, Singer BH, Utzinger J (2008b). *The 6/94 gap in health impact assessment*. Environmental Impact Assessment Review 28: 349-358.

Erlanger TE, Sayasone S, Krieger GR, Kaul S, Sananikhom P, Tanner M, Odermatt P, Utzinger J (2008a). *Baseline health situation of communities affected by the Nam Theun 2 hydroelectric project in central Lao PDR and indicators for monitoring*. International Journal of Environmental and Health Research 18: 223-242.

Ewan C, Young A, Bryant E, Calvert D (1994). *National framework for environmental and health impact assessment*. Canberra, Australia: National Health and Medical Research Council, Australian Government Publishing Service.

Fearnside PM (2005). *Brazil's Samuel Dam: lessons for hydroelectric development policy and the environment in Amazonia*. Environmental Management 35: 1-19.

Fehr R (1999). *Environmental health impact assessment: evaluation of a ten-step model*. Epidemiology 10: 618-625.

Fehr R, Mekel O, Lacombe M, Wolf U (2003). *Towards health impact assessment of drinking-water privatization: the example of waterborne carcinogens in North Rhine-Westphalia (Germany)*. Bulletin of the World Health Organization 81: 408-414.

Fewtrell L, Kay D (2008a). *Concluding remarks*. In: Fewtrell L, Kay D, editors. Health impact assessment for sustainable water management. London, U.K.: IWA Publishing pp. 249-264.

Fewtrell L, Kay D (2008b). *Health impact assessment for sustainable water management*. London, U.K.: IWA Publishing.

Finer D, Tillgren P, Berensson K, Guldbrandsson K, Haglund BJA (2005). *Implementation of a health impact assessment (HIA) tool in a regional health organization in Sweden: a feasibility study*. Health Promotion International 20: 277-284.

Fogel RW (2004). *The escape form hunger and premature death*. London, U.K.: Cambridge University Press.

Guerra CA, Snow RW, Hay SI (2006). *Mapping the global extent of malaria in 2005*. Trends in Parasitology 22: 353-358.

Harris-Roxas B (2011). *Health impact assessment in the Asia Pacific*. Environmental Impact Assessment Review 31: 393-395.

Harris-Roxas B, Harris PJ (2007). *Learning by doing: the value of case studies of health impact assessment*. New South Wales Public Health Bulletin 18: 161-163.

Harris P, Harris-Roxas B, Harris E, Kemp L (2007). *Health impact assessment: a practical guide.* Sydney, Australia: University of New South Wales Reasearch Centre for Primary Health Care and Equity and New South Wales Health.

Harris P, Spickett J (2011). *Health impact assessment in Australia: a review and directions for progress*. Environmental Impact Assessment Review 31: 425-432.

Hay SI, Guerra CA, Gething PW, Patil AP, Tatem AJ, Noor AM, Kabaria CW, Manh BH, Elyazar IRF, Brooker S, Smith DL, Moyeed RA, Snow RW (2009). *A world malaria map: Plasmodium falciparum endemicity in 2007*. PLoS Medicine 6: e1000048.

Health Canada (1999). *The Canadian handbook on health impact assessment*. Ottawa, Canada: Ministry of Health.

Huang Z (2011). *Health impact assessment in China: emergence, progress and challenges*. Environmental Impact Assessment Review In press, doi: 10.1016/j.eiar.2011.03.001.

Hübel M, Hedin A (2003). *Developing health impact assessment in the European Union*. Bulletin of the World Health Organization 81: 463-464.

Humphries J (2010). *Childhood and child labour in the British industrial revolution*. New York, U.S.: Cambridge University Press.

ICMM (2010). *Good practice guidance on health impact assessment*. London, U.K.: International Council on Minerals & Metals [http://www.icmm.com/page/35457/good-practice-guidance-on-health-impact-assessment; accessed: 9 May 2011].

IFC (2006). *Performance standards*. Washington, D.C., U.S.: International Finance Corporation [http://www.ifc.org/ifcext/sustainability.nsf/Content/PerformanceStandards; accessed: 9 May 2011].

IFC (2009). *Introduction to health impact assessment*. Washington, D.C., U.S.: International Finance Corporation [http://www.ifc.org/ifcext/sustainability.nsf/Content/Publications_Handbook_HealthImpactAssessment; accessed: 9 May 2011].

IPIECA (2005). *A guide to health impact assessment in the oil and gas industry*. London, U.K.: International Petroleum Industry Environmental Conservation Association [http://www.ipieca.org/system/files/publications/HPI.pdf; accessed: 9 May 2011].

Jobin W (2003). *Health and equity impacts of a large oil project in Africa*. Bulletin of the World Health Organization 81: 420-426.

Joffe M, Mindell J (2002). *A framework for the evidence base to support health impact assessment*. Journal of Epidemiology and Community Health 56: 132-138.

Joffe M, Mindell J (2005). *Health impact assessment*. Occupational and Environmental Medicine 62: 907-912.

Kang E, Lee Y, Harris P, Koh K, Kim K (2011). *Health impact assessment in Korea*. Environmental Impact Assessment Review 31: 438-440.

Kemm J (2001). *Health impact assessment: a tool for healthy public policy*. Health Promotion International 16: 79-85.

Kemm J (2003). *Perspectives on health impact assessment*. Bulletin of the World Health Organization 81: 387-387.

Kemm J (2005). *The future challenges for HIA*. Environmental Impact Assessment Review 25: 799-807.

Kemm J, Parry J (2004). *What is HIA? Introduction and overview.* In: Kemm J, Parry J, Palmer S, editors. Health impact assessment: concepts, theory, techniques, and applications. Oxford, UK: Oxford University Press pp. 1-13.

Kemm J, Parry J, Palmer S (2004). *Health impact assessment: concepts, theory, techniques, and applications*. Oxford, U.K.: Oxford University Press.

Kittinger JN, Coontz KM, Yuan ZP, Han DJ, Zhao XF, Wilcox BA (2009). *Toward holistic evaluation and assessment: linking ecosystems and human well-being for the Three Gorges Dam*. EcoHealth 6: 601-613.

Krieger GR, Balge MZ, Chanthaphone S, Tanner M, Singer BH, Fewtrell L, Kaul S, Sananikhom P, Odermatt P, Utzinger J (2008). *Nam Theum 2 hydroelectric project, Lao PDR*. In: Fewtrell L, Kay D, editors. Health impact assessment for sustainable water management. London, U.K.: IWA Publishing pp. 199-232.

Krieger N, Northridge M, Gruskin S, Quinn M, Kriebel D, Smith GD, Bassett M, Rehkopf DH, Miller C (2003). *Assessing health impact assessment: multidisciplinary and international perspectives*. Journal of Epidemiology and Community Health 57: 659-662.

Lebret E, Staatsen B (2002). *Health impact assessment, current practice in the Netherlands*. Epidemiology 13: S131-S131.

Lerer LB (1999). *Health impact assessment*. Health Policy and Planning 14: 198-203.

Lerer LB, Scudder T (1999). *Health impacts of large dams*. Environmental Impact Assessment Review 19: 113-123.

Lock K (2000). *Health impact assessment*. BMJ 320: 1395-1398.

Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJL (2006). *Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data*. Lancet 367: 1747-1757.

Mahoney M (2007). *Health impact assessment in a policy context.* In: Barraclough S, Gardner H, editors. Analysing health policy: a problem-oriented approach. Sydney, Australia: Elsevier Australia pp.

Mahoney M, Morgan RK (2001). *Health impact assessment in Australia and New Zealand: an exploration of methodological concerns*. Promotion and Education 8: 8-11.

Marriott BB (1997). *Environmental impact assessment: a practical guide*. New York, U.S.: The McGraw-Hill Companies.

Meier GM, Rauch JE (2000). *Leading issues in economic development*. New York, U.S.: Oxford University Press.

Mekel O, Haigh F, Fehr R, Scott-Samuel A, Abrahams D, Pennington A, den Broeder L, Doyle C, Metcalfe O (2004). *Policy health impact assessment for the European Union*. Gesundheitswesen 66: 638-638.

Milio N (1981). *Promoting health through public policy*. Philadelphia, U.S.: FA Davis Company.

Mindell J, Biddulph J, Taylor L, Lock K, Boaz A, Joffe M, Curtis S (2010). *Improving the use of evidence in health impact assessment*. Bulletin of the World Health Organization 88: 543-550.

Mindell J, Boaz A, Joffe M, Curtis S, Birley M (2004). *Enhancing the evidence base for health impact assessment*. Journal of Epidemiology and Community Health 58: 546-551.

Mindell J, Boltong A, Forde I (2008). *A review of health impact assessment frameworks*. Public Health 122: 1177-1187.

Moyo D (2009). *Dead aid*. London, U.K.: Penguin Books.

Neate P (2000). *Musungu Jim and the great chief Tuloko*. Harmondsworth, U.K.: Penguin Books Ltd.

NEPA (1970). *National environmental policy act of 1969*. Washington, D.C., U.S.: U.S. Environmental Protection Agency.

O'Connell E, Hurley F (2009). *A review of the strengths and weaknesses of quantitative methods used in health impact assessment*. Public Health 123: 306-310.

O'Sullivan A, Sheffrin SM (2002). *Economics: principles in action*. Upper Saddle River, U.S.: Pearson Prentice Hall.

Oster E (2005). *Sexually transmitted infections, sexual behavior, and the HIV/AIDS epidemic*. Quarterly Journal of Economics 120: 467-515.

Parry J, Stevens A (2001). *Prospective health impact assessment: pitfalls, problems, and possible ways forward*. BMJ 323: 1177-1182.

Phoolcharoen W, Sukkumnoed D, Kessomboon P (2003). *Development of health impact assessment in Thailand: recent experiences and challenges*. Bulletin of the World Health Organization 81: 465-467.

Population Health Resource Branch (1995). *Health impact assessment toolkit: a resource for government analysts*. Victoria, British Columbia: Ministry of Health.

Public Health Commission (1995). *A guide for health impact assessment*. Wellington, New Zealand: Public Health Commission.

Putters K (2005). *HIA, the next step: defining models and roles*. Environmental Impact Assessment Review 25: 693-701.

Quigley RJ, Taylor LC (2003). *Evaluation as a key part of health impact assessment: the English experience*. Bulletin of the World Health Organization 81: 415-419.

Quigley RJ, Taylor LC (2004). *Evaluating health impact assessment*. Public Health 118: 544-552.

Quigley RL, den Broeder P, Furu A, Bond B, Cave B, Bos R (2006). *Health impact assessment international best practice principles. Special Publication Series No. 5*. Fargo, USA: International Association for Impact Assessment.

Ratner PA, Green LW, Frankish CJ, Chomik T, Larsen C (1997). *Setting the stage for health impact assessment*. Journal of Public Health Policy 18: 67-79.

Sachs J (2005). *The end of poverty: how we can make it happen in our lifetime*. London, U.K.: Penguin Books.

Salay R, Lincoln P (2008). *Health impact assessment in the European Union*. Lancet 372: 860-861.

Scott-Samuel A (1996). *Health impact assessment: an idea whose time has come*. BMJ 313: 183-184.

Scott-Samuel A (1998). *Health impact assessment: theory into practice*. Journal of Epidemiology and Community Health 52: 704-705.

Scott-Samuel A (2005). *Health impact assessment: an international perspective*. New South Wales Public Health Bulletin 16: 110-3.

Sicilia AR, Purroy CA (2008). *Health impact assessment: the state of the art*. Gaceta Sanitaria 22: 348-353.

Singer BH, Castro MC (2007). *Bridges to sustainable tropical health*. Proceedings of the National Academy of Sciences of the United States of America 104: 16038-16043.

Smith BJ, Tang KC, Nutbeam D (2006). *WHO health promotion glossary: new terms*. Health Promotion International 21: 340-345.

Spickett JT, Brown HL, Katscherian D (2011). *Adaptation strategies for health impacts of climate change in Western Australia: application of a health impact assessment framework*. Environmental Impact Assessment Review 31: 297-300.

Ståhl T, Wismar M, Ollila E, Lahtinen E, Leppo K (2006). *Health in all policies: prospects and potentials*. Brussels, Belgium: Ministry of Social Affaires and Health Finnland and European Observatory on Health Systems and Policies.

Steinmann P, Keiser J, Bos R, Tanner M, Utzinger J (2006). *Schistosomiasis and water resources development: systematic review, meta-analysis, and estimates of people at risk*. Lancet Infectious Diseases 6: 411-425.

Thamlikitkul V (2006). *Bridging the gap between knowledge and action for health: case studies*. Bulletin of the World Health Organization 84: 603-607.

Utzinger J, Wyss K, Moto DD, Yemadji N, Tanner M, Singer BH (2005). *Assessing health impacts of the Chad-Cameroon petroleum development and pipeline project: challenges and a way forward*. Environmental Impact Assessment Review 25: 63-93.

Veerman JL, Barendregt JJ, Mackenbach JP (2005). *Quantitative health impact assessment: current practice and future directions*. Journal of Epidemiology and Community Health 59: 361-370.

Veerman JL, Mackenbach JP, Barendregt JJ (2007). *Validity of predictions in health impact assessment*. Journal of Epidemiology and Community Health 61: 362-366.

Vohra S (2007). *International perspective on health impact assessment in urban settings*. New South Wales Public Health Bulletin 18: 152-4.

WHO (1986). *The Ottawa Charter for health promotion*. Geneva, Switzerland: World Health Organization.

WHO (2001). *Health impact assessment: harmonization, mainstreaming and capacity building.* Report of an inter-regional meeting on harmonization and mainstreaming of HIA in the World Health Organization and of a partnership meeting on the institutionalization of HIA capacity building in Africa, Arusha, 31 October-3 November 2000. Geneva, Switzerland: World Health Organization.

WHO (2011). *Health impact assessment*. Geneva, Switzerland: World Health Organization [http://www.who.int/hia/en/; accessed: 9 May 2011].

WHO Representative Office in Vietnam (2009). *Environmental health*. Manila, Philipines: WHO Regional Office for the Western Pacific [http://www.wpro.who.int/vietnam/sites/dhs/environment/; accessed: 9 May 2011].

WHO/ECHP (1999). *Health impact assessment: main concepts and suggested approach. Gothenburg consensus paper*. Copenhagen, Sweden: WHO Regional Office Europe.

Winkler MS (2009). *Presentation: health impact assessment in complex eco-epidemiological settings: advancing tools and methods*. Basel, Switzerland: Swiss Tropical Institute Symposium.

Wismar M (2005). *Health impact assessment: objectivity and effect in the European comparison*. Gesundheitswesen 67: 532-532.

Wright J, Parry J, Mathers J (2005). *Participation in health impact assessment: objectives, methods and core values*. Bulletin of the World Health Organization 83: 58-63.

Wu L, Rutherford S, Chu C (2011). *The need for health impact assessment in China: potential benefits for public health and steps forward*. Environmental Impact Assessment Review 31: 420-424.

Yewhalaw D, Legesse W, Van Bortel W, Gebre-Selassie S, Kloos H, Duchateau L, Speybroeck N (2009). *Malaria and water resource development: the case of Gilgel-Gibe hydroelectric dam in Ethiopia*. Malaria Journal 8: 21.

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

Mirko S. Winkler[a,b], Mark J. Divall[b], Gary R. Krieger[c], Marci Z. Balge[c], Burton H. Singer[d], Jürg Utzinger[a,*]

[a] Department of Public Health and Epidemiology, Swiss Tropical Institute, CH-4002 Basel, Switzerland

[b] NewFields, LLC, Pretoria 0062, South Africa

[c] NewFields, LLC, Denver, CO 80202, USA

[d] Office of Population Research, Princeton University, Princeton, NJ 08544, USA

Corresponding author

* Jürg Utzinger, Department of Public Health and Epidemiology, Swiss Tropical Institute, CH-4002 Basel, Switzerland. Tel.: +41 61 284-8129; fax: +41 61 284-8105; E-mail address: juerg.utzinger@unibas.ch (J. Utzinger).

This article has been published in

Environmental Impact Assessment Review 2010, 30: 52-61

2.1. 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 HIA have been performed. Hence, more HIA 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 frame 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.

Keywords: Health impact assessment; Developing countries; Environmental health areas; Risk analysis matrix; Gold mining project; Democratic Republic of the Congo

2.2. 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-Odei 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; Krieger et al., 2008; Erlanger et al., 2008b).

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 minimised 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 institutionalised 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 HIA 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 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). 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., 2008b; 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 facilitate the promotion of a sustainable public-health policy in the developing world.

2.3. Project description

2.3.1. 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 km^2 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 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.

2.3.2. 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 (Figure 2.1). 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).

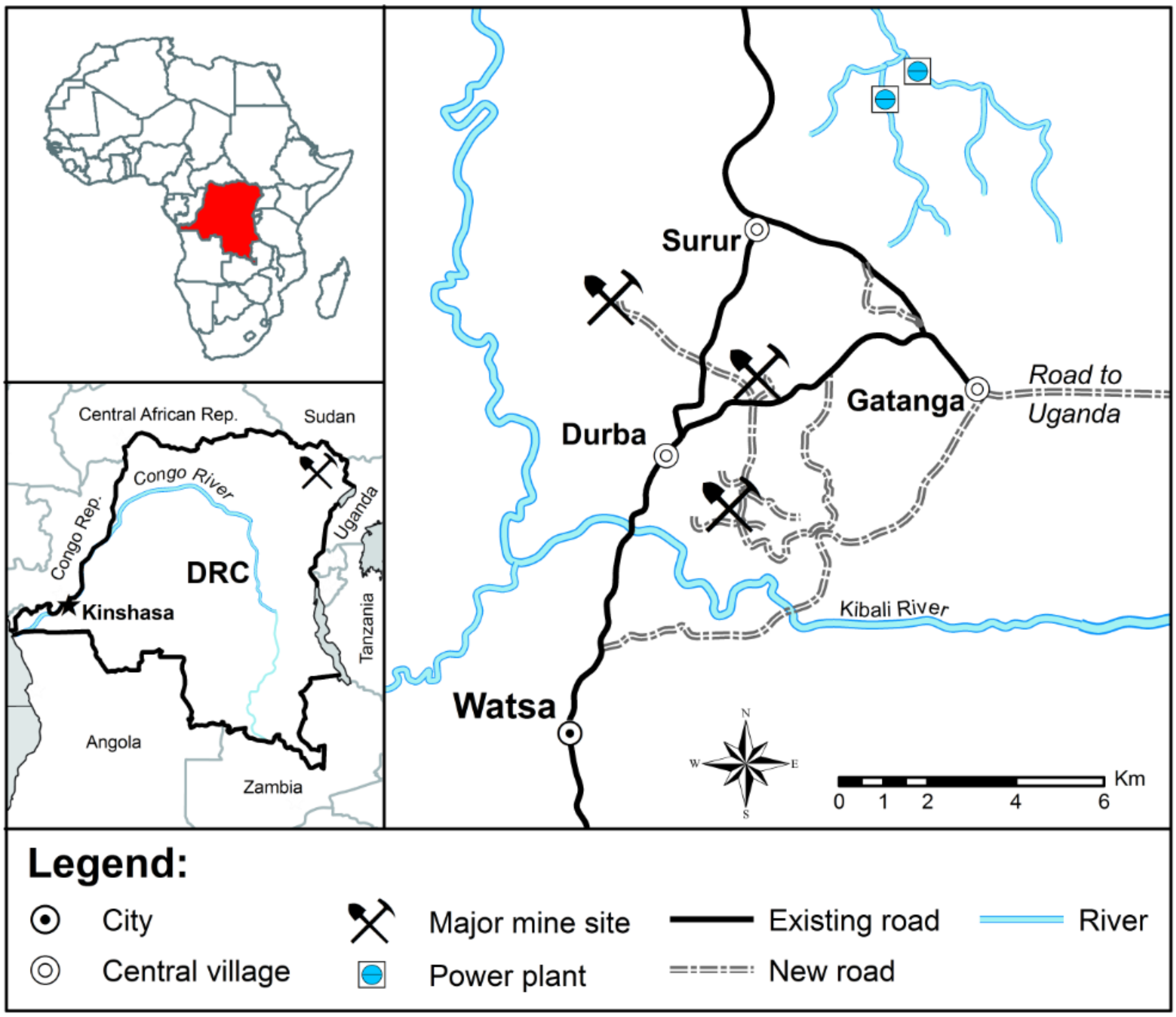


Figure 2.1: Map showing the location of the Moto Goldmines project in the north-eastern part of DRC and major planned developments.

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 in-migration by job seekers and/or small-scale service providers will then occur (IFC, 2009a). 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).

2.3.3. 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).

2.4. Health impact assessment

2.4.1. 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). 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 haemorrhagic 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 (KIIs) 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 (Figure 2.2). 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.

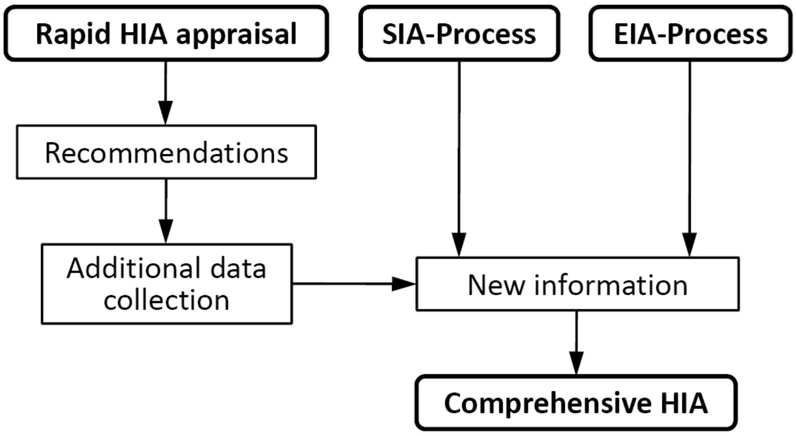


Figure 2.2: Iterative HIA process adapted for the Moto Goldmines project in DRC.

2.4.2. 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, KIIs 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 KIIs 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) emphasising public-health issues were absent in the project area, and hence this source of potential information could not be tapped. Additional KIIs 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.

2.4.3. 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; IFC, 2008; Erlanger et al., 2008b; IFC, 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., 2008b). The 12 EHAs utilized in our analysis are summarized in Table 2.1.

Table 2.1: Environmental health areas (adapted from IFC guideline (2009a)).

No.	Environmental health area	Description
1	Communicable diseases	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
2	Vector-related diseases	Mosquito, fly, tick and lice-related diseases (e.g. malaria, dengue, yellow fever, lymphatic filariasis, leishmaniasis, human African trypanosomiasis, onchocerciasis, etc.)
3	Soil-, water- and waste-related diseases	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 heminthiases, etc.)
4	Sexually-transmitted infections, including HIV/AIDS	Sexually-transmitted infections such as syphilis, gonorrhoea, Chlamydia, hepatitis B and, most importantly, HIV/AIDS
5	Food- and nutrition-related issues	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.
6	Non-communicable diseases	Cardiovascular diseases, cancer, diabetes, obesity, etc.
7	Accidents/injuries	Road traffic or work-related accidents and injuries (home and project related); drowning
8	Veterinary medicine and zoonotic diseases	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.)
9	Exposure to potentially hazardous materials, noise and malodours	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
10	Social determinants of health	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.
11	Cultural health practices	Role of traditional medical providers, indigenous medicines, and unique cultural health practices
12	Health systems issues	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.)

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.

2.4.4. Community profiling

The preceding SIA revealed that there were an estimated 11,523 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 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 boarder.

2.4.5. 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 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) extent; (ii) intensity; (iii) duration; and (iv) health effect – is rated according to the criteria set forth in Figure 2.3. 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 Figure 2.3. 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 KIIs 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.

Step 1				
Impact level (Score)	**Consequences**			
	A – Extent	**B – Intensity**	**C – Duration**	**D – Health Effect**
Low (0)	Punctual Rare individual cases	Minor intensity	< 1 month	Health effect is not perceptible
Medium (1)	Local: small and limited A small number of households is affected	Those impacted will be able to adapt to the health impact with ease and maintain pre-impact level of health	Short-term 1-12 month Low frequency	Health effect resulting in annoyance, minor injuries or illness that does not require hospitalisation
High (2)	Project area: medium but localised Village level	Those impacted will be able to adapt to the health impact with some difficulty and will maintain pre-impact level of health with support	Medium term 1-6 years Medium or intermittent frequency	Health effect resulting in moderate injury or illness that may require hospitalisation
Very high (3)	Extends beyond the project area Regional level	Those impacted will not be able to adapt to the health impact or to maintain pre-impact level of health	Long-term/irreversible > 6 years Constant frequency	Health effect resulting in loss of life, severe injuries or chronic illness that may require hospitalisation

Step 2	***Step 3*** **Likelihood**			
Impact severity (Score range of A+B+C+D)	**Improbable** (< 40%)[a]	**Possible** (40% - 70%)[a]	**Probable** (70% - 90%)[a]	**Definite** (> 90%)[a]
	Step 4 **Significance rating**			
Low (0 – 3)	♦	♦	♦	♦♦
Medium (4 – 6)	♦	♦♦	♦♦	♦♦♦
High (7 – 9)	♦♦	♦♦♦	♦♦♦	♦♦♦♦
Very high (10 – 12)	♦♦♦	♦♦♦♦	♦♦♦♦	♦♦♦♦

Figure 2.3: Risk assessment matrix including the four working steps of the appraisal.
([a] likelihood of occurrence; significance rating: ♦ low; ♦♦ medium; ♦♦♦ high; ♦♦♦♦ very high)

2.4.6. 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.

2.5. 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.

2.5.1. 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, KIIs 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 emphasised 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.

2.5.2. 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 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 2.2 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 KABP 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.

Table 2.2: Risk analysis for EHA 4: sexually-transmitted infections, including HIV/AIDS.

	Consequences						
Condition	Extent	Intensity	Duration	Health effects	Impact severity	Likelihood	Significance
Baseline	Project area (2)	High (3)	Long term (3)	High (3)	Very high (11)	Definite	♦♦♦♦
Without mitigation	Regional level (3)	High (3)	Long term (3)	High (3)	Very high (12)	Definite	♦♦♦♦↓
Residual	Project area (2)	Medium (2)	Long term (3)	Medium (2)	High (9)	Possible	♦♦♦↑

(Significances: ♦♦♦ high; ♦♦♦♦ very high; ↓ aggravation compared to baseline; ↑ improvement compared to baseline)

2.5.3. Significance of potential health impacts and recommendations

Table 2.3 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.

Table 2.3: Summary table of potential health impacts of the Moto Goldmines project.

Environmental health areas		Significance			Potentially affected communities				
No.	Specific health impacts	Baseline	Without Mitigation	Residual	PAC1	PAC2	PAC3	PAC4	PAC5
1	Communicable diseases	♦♦♦	♦♦♦♦$^{\downarrow}$	♦♦$^{\uparrow}$	x	x	x	x	
2	Vector-related diseases								
	Malaria	♦♦♦♦	♦♦♦♦$^{\downarrow}$	♦♦$^{\uparrow}$	x	x	x	x	
	Arboviruses	♦♦♦	♦♦♦	♦♦$^{\uparrow}$	x	x	x	x	
3	Soil-, water- and waste-related diseases	♦♦♦	♦♦♦♦$^{\downarrow}$	♦♦$^{\uparrow}$	x	x	x	x	
4	Sexually-transmitted infections, including HIV/AIDS	♦♦♦♦	♦♦♦♦$^{\downarrow}$	♦♦♦$^{\uparrow}$	x	x	x	x	x
5	Food-and nutrition-related issues								
	Malnutrition	♦♦	♦♦♦$^{\downarrow}$	♦♦	x	x	x	x	
6	Non-communicable diseases	♦♦♦	♦♦♦♦$^{\downarrow}$	♦♦♦	x	x	x	x	
7	Accidents/injuries	♦	♦♦♦♦$^{\downarrow}$	♦♦$^{\downarrow}$	x	x	x	x	x
8	Veterinary medicine and zoonotic diseases								
	Viral hemorrhagic fever	♦♦♦	♦♦♦	♦$^{\uparrow}$	x	x	x	x	x
9	Exposure to potentially hazardous materials, noise and malodours	♦♦♦	♦♦♦	♦$^{\uparrow}$	x	x	x	x	x
10	Social determinants of health								
	Life style	♦♦	♦♦♦$^{\downarrow}$	♦♦	x	x	x	x	x
11	Cultural health practices	♦♦♦	♦♦♦	+	x	x	x	x	
12	Health systems issues								
	Infrastructure and capacity	♦♦♦	♦♦♦♦$^{\downarrow}$	+	x	x	x	x	
	Maternal health	♦♦	♦♦	♦$^{\uparrow}$	x	x	x	x	
	Child health	♦♦♦	♦♦♦	♦♦$^{\uparrow}$	x	x	x	x	
	Programme management and delivery systems	♦♦	♦♦♦$^{\downarrow}$	+	x	x	x	x	x

(Significances: ♦ low; ♦♦ medium; ♦♦♦ high; ♦♦♦♦ very high; $^{\downarrow}$ aggravation compared to baseline; $^{\uparrow}$ improvement compared to baseline; + potential for positive effect; x affected)

2.6. Discussion

2.6.1. 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 minimised, 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.

2.6.2. 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).

2.7. 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 underdeveloped, 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.

2.8. Acknowledgements

We thank Paul Schmiede and colleagues from Moto Goldmines Limited for access to project-related data, the three medical doctors of the major regional health facilities for their time and commitment, the community health representative of the project for her support and contribution, and the participants of the FGDs for their kind collaboration and interest. Mirko S. Winkler is grateful to NewFields for a PhD fellowship and Jürg Utzinger acknowledges financial support from the Swiss National Science Foundation (project no. PPOOB-102883, PPOOB-119129).

2.9. References

Asamoah-Odei E, Calleja JMG, Boerma JT (2004). *HIV prevalence and trends in sub-Saharan Africa: no decline and large subregional differences*. Lancet 364: 35-40.

Auvert B, Ballard R, Campbell C, Carael M, Carton M, Fehler G, Gouws E, MacPhail C, Taljaard D, Van Dam J, Williams B (2001). *HIV infection among youth in a South African mining town is associated with herpes simplex virus-2 seropositivity and sexual behaviour*. AIDS 15: 885-898.

Bausch DG, Nichol ST, Muyembe-Tamfum JJ, Borchert M, Rollin PE, Sleurs H, Campbell P, Tshioko FK, Roth C, Colebunders R, Pirard P, Mardel S, Olinda LA, Zeller H, Tshomba A, Kulidri A, Libande ML, Mulangu S, Formenty P, et al. (2006). *Marburg hemorrhagic fever associated with multiple genetic lineages of virus*. New England Journal of Medicine 355: 909-919.

Birley MH (2005). *Health impact assessment in multinationals: a case study of the Royal Dutch/Shell Group*. Environmental Impact Assessment Review 25: 702-713.

BMC (2008). *Borgakim Medical Centre: first term medical report 2008:* Doko, Democratic Republic of the Congo: Borgakim Medical Centre.

Bos R (2006). *Health impact assessment and health promotion*. Bulletin of the World Health Organization 84: 914-915.

Caussy D, Kumar P, Sein UT (2003). *Health impact assessment needs in south-east Asian countries*. Bulletin of the World Health Organization 81: 439-443.

Chen S, Ravallion M (2008). *The developing World is poorer than we thought, but no less successful in the fight against poverty*. World Bank policy research working paper No. 4703. Washington, D.C., U.S.: Development Research Group, The World Bank.

Cole BL, Shimkhada R, Fielding JE, Kominski G, Morgenstern H (2005). *Methodologies for realizing the potential of health impact assessment*. American Journal of Preventive Medicine 28: 382-389.

Cube Consulting (2008). *Independent technical report: Moto Goldmines Project, Democratic Republic of the Congo*. Perth, Australia: Cube Consulting.

De Cock KM (2001). *Epidemiology and the emergence of human immunodeficiency virus and acquired immune deficiency syndrome*. Philosophical Transactions of the Royal Society B: Biological Sciences 356: 795-798.

Divall MJ, Winkler MS (2008). *Rapid health impact assessment: Moto Goldmines Project, Democratic Repoblic of the Congo*. Pretoria, South Africa: NewFields.

Equator Principles (2006). *The equator principles*. London, U.K.: The Equator Principles Association [http://www.equator-principles.com; accessed: 5 May 2009].

Erlanger TE, Krieger GR, Singer BH, Utzinger J (2008a). *The 6/94 gap in health impact assessment*. Environmental Impact Assessment Review 28: 349-358.

Fearnside PM (2005). *Brazil's Samuel Dam: lessons for hydroelectric development policy and the environment in Amazonia*. Environmental Management 35: 1-19.

Fewtrell L, Kay D, McDonald A (2008). *Rainwater harvesting: an HIA of rainwater harvesting in the UK*. In: Fewtrell L, Kay D, editors. Health impact assessment for sustainable water management. London, U.K.: IWA Publishing pp. 45-68.

Freeman EE, Orroth KK, White RG, Glynn JR, Bakker R, Boily MC, Habbema D, Buve A, Hayes RJ (2007). *Proportion of new HIV infections attributable to herpes simplex 2 increases over time: simulations of the changing role of sexually transmitted infections in sub-Saharan African HIV epidemics*. Sexually Transmitted Infections 83: I17-I24.

Giles J (2006). *Tide of censure for African dams*. Nature 440: 393-394.

Gilgen D, Williams BG, MacPhail C, van Dam CJ, Campbell C, Ballard RC, Taljaard D (2001). *The natural history of HIV/AIDS in a major goldmining centre in South*

Africa: results of a biomedical and social survey. South African Journal of Science 97: 387-392.

Grosskurth H, Mosha F, Todd J, Mwijarubi E, Klokke A, Senkoro K, Mayaud P, Changalucha J, Nicoll A, Kagina G, Newell J, Mugeye K, Mabey D, Hayes R (1995). *Impact of improved treatment of sexually-transmitted diseases on HIV-infection in rural Tanzania: randomized controlled trial*. Lancet 346: 530-536.

Guerra CA, Snow RW, Hay SI (2006). *Mapping the global extent of malaria in 2005*. Trends in Parasitology 22: 353-358.

Hennink MM (2007). *International focus group research: a handbook for the health and social sciences*. New York, U.S.: Cambridge University Press.

HSE (2008). *ALARP "at a glance"*. London, U.K.: Health and Safety Executive [http://www.hse.gov.uk/risk/theory/alarpglance.htm; accessed: 5 May 2009].

Hubel M, Hedin A (2003). *Developing health impact assessment in the European Union*. Bulletin of the World Health Organization 81: 463-464.

IFC (2006). *Performance standards*. Washington, D.C., U.S.: International Finance Corporation [http://www.ifc.org/ifcext/sustainability.nsf/Content/PerformanceStandards; accessed: 5 May 2009].

IFC (2007). *Stakeholder engagement: a good practice handbook for companies doing business in emerging markets*. Washington, D.C., U.S.: International Finance Corporation [http://www.ifc.org/ifcext/sustainability.nsf/Content/Publications_GoodPractice_StakeholderEngagement; accessed: 2 September 2010].

IFC (2008). *Good practice documents*. Washington, D.C., U.S.: International Finance Corporation [http://www.ifc.org/ifcext/sustainability.nsf/Content/Publications_GoodPractice; accessed: 5 May 2009].

IFC (2009a). *Introduction to health impact assessment*. Washington, D.C., U.S.: International Finance Corporation [http://www.ifc.org/ifcext/sustainability.nsf/Content/Publications_GoodPractice_HealthAssessment; accessed: 5 May 2009].

IFC (2009b). *The Migration Effect: risk assessment and management strategies for addressing project-induced in-migration (draft)*. Washington, D.C., U.S.: International Finance Corporation [http://www.ifc.org/ifcext/sustainability.nsf/Content/PublicComment_InfluxManagement; accessed: 5 May 2009].

IPIECA (2005). *A guide to health impact assessment in the oil and gas industry*. London, U.K.: International Petroleum Industry Environmental Conservation Association and International Association of Oil & Gas Producers [http://www.ipieca.org/system/files/publications/HPI.pdf; accessed: 5 May 2009].

Jobin W (2003). *Health and equity impacts of a large oil project in Africa*. Bulletin of the World Health Organization 81: 420-426.

Joffe M (2003). *How do we make health impact assessment fit for purpose?* Public Health 117: 301-304.

Joffe M, Mindell J (2005). *Health impact assessment*. Occupational and Environmental Medicine 62: 907-912.

Katz R, Singer B (2007). *Can an attribution assessment be made for Yellow Rain? Systematic reanalysis in a chemical-and-biological-weapons use investigation*. Politics and the Life Sciences 26: 24-42.

Kemm J (2001). *Health impact assessment: a tool for healthy public policy*. Health Promotion International 16: 79-85.

Kemm J (2005). *The future challenges for HIA*. Environmental Impact Assessment Review 25: 799-807.

Krieger GR, Balge MZ, Chanthaphone S, Tanner M, Singer BH, Fewtrell L, Kaul S, Sananikhom P, Odermatt P, Utzinger J (2008). *Nam Theum 2 hydroelectric project, Lao PDR*. In: Fewtrell L, Kay D, editors. Health impact assessment for sustainable water management. London, U.K.: IWA Publishing.

Krieger N, Northridge M, Gruskin S, Quinn M, Kriebel D, Smith GD, Bassett M, Rehkopf DH, Miller C (2003). *Assessing health impact assessment: multidisciplinary and international perspectives*. Journal of Epidemiology and Community Health 57: 659-662.

Lerer LB, Scudder T (1999). *Health impacts of large dams*. Environmental Impact Assessment Review 19: 113-123.

Listorti JA (1996). *Bridging environmental health gaps. Lessons for sub-Saharan Africa infrastructure projects*. AFTES Working paper No. 20. Washington, D.C., U.S.: Environmental Sustainable Development Division. Africa Technical Department: The World Bank.

Listorti JA, Doumani FM (2001). *Environmental health: bridging the gaps*. The World Bank Discussion Paper No. 422. Washington, D.C., U.S.: The World Bank Group.

Lock K (2000). *Health impact assessment*. BMJ 320: 1395-1398.

Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJL (2006). *Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data*. Lancet 367: 1747-1757.

Lutz W, Qiang R (2002). *Determinants of human population growth*. Philosophical Transactions of the Royal Society B: Biological Sciences 357: 1197-1210.

McMahon G, Remy F (2001). *Large mines and the community: socioeconomic and environmental effects in Latin America, Canada, and Spain*. Washington, D.C., U.S.: The World Bank.

MEASURE DHS (2008). *Enquête démographique et de santé: République Démocratique du Congo 2007*. Kinshasa, Democratic Republic of the Congo: Ministère du Plan avec la collaboration du Ministère de la Santé [http://www.measuredhs.com/pubs/pdf/FR208/FR208.pdf; accessed: 5 May 2009].

Mekonnen Y, Sanders E, Messele T, Wolday D, Dorigo-Zestma W, Schaap A, Mekonnen W, Meless H, Mihret W, Fontanet A, Coutinho RA, Dukers N (2005). *Prevalence and incidence of, and risk factors for, HIV-1 infection among factory workers in Ethiopia, 1997-2001*. Journal of Health Population and Nutrition 23: 358-368.

Mercier JR (2003). *Health impact assessment in international development assistance: the World Bank experience*. Bulletin of the World Health Organization 81: 461-462.

MGL (2009). *Official homepage of the Moto Gold Project*. Perth, Australia: Moto Goldmines Ltd. [http://www.motogoldmines.com; accessed: 5 May 2009].

Mindell J, Boaz A, Joffe M, Curtis S, Birley M (2004). *Enhancing the evidence base for health impact assessment*. Journal of Epidemiology and Community Health 58: 546-551.

Mindell J, Hansell A, Morrison D, Douglas M, Joffe M (2001). *What do we need for robust, quantitative health impact assessment?* Journal of Public Health Medicine 23: 173-178.

Mining Code DRC (2002). *Loi N° 007/2002 du 11 Juillet 2002 portant Code Minier*. Kinshasa, Democratic Republic of the Congo: Ministère des Mines et Hydrocarbures [http://www.droit-afrique.com/images/textes/RDC/; accessed: 5 May 2009].

Oster E (2005). *Sexually transmitted infections, sexual behavior, and the HIV/AIDS epidemic*. Quarterly Journal of Economics 120: 467-515.

Parry J, Stevens A (2001). *Prospective health impact assessment: pitfalls, problems, and possible ways forward*. BMJ 323: 1177-1182.

Phoolcharoen W, Sukkumnoed D, Kessomboon P (2003). *Development of health impact assessment in Thailand: recent experiences and challenges*. Bulletin of the World Health Organization 81: 465-467.

Potts M, Halperin DT, Kirby D, Swidler A, Marseille E, Klausner JD, Hearst N, Wamai RG, Kahn JG, Walsh J (2008). *Public health: reassessing HIV prevention*. Science 320: 749-750.

PRB (2009). *Official website*. Washington, D.C., U.S.: Population reference bureau [http://www.prb.org; accessed: 5 May 2009].

Putters K (2005). *HIA, the next step: defining models and roles*. Environmental Impact Assessment Review 25: 693-701.

RADS (2009). *Resettlement policy framework report: Moto Goldmines Project, Democratic Repoblic of the Congo*. Durban, South Africa: Resettlement And Development Solutions.

Rowe G, Wright G (1999). *The Delphi technique as a forecasting tool: issues and analysis*. International Journal of Forecasting 15: 353-375.

Scott-Samuel A (1998). *Health impact assessment: theory into practice*. Journal of Epidemiology and Community Health 52: 704-705.

Scott-Samuel A (2005). *Health impact assessment: an international perspective*. New South Wales Public Health Bulletin 16: 110-3.

Singer BH, Castro MC (2007). *Bridges to sustainable tropical health*. Proceedings of the National Academy of Sciences of the United States of America 104: 16038-16043.

Steinmann P, Keiser J, Bos R, Tanner M, Utzinger J (2006). *Schistosomiasis and water resources development: systematic review, meta-analysis, and estimates of people at risk*. Lancet 6: 411-425.

Synergy (2009). *Community and social development optimisation report: Moto Goldmines Project, Democratic Repoblic of the Congo*. Johannesburg, South Africa: Synergy.

Traub J (2006). *China's Africa adventure*. New York, U.S.: New York Times.

UNAIDS/WHO (2008). *Epidemiological fact sheet on HIV and AIDS, core data on epidemiology and response, Democratic Republic of the Congo*. Geneva, Switzerland: World Health Organization [http://www.who.int/globalatlas/predefinedReports/EFS2008/full/EFS2008_CD.pdf; accessed: 5 May 2009].

Upton M (2008). *Safeguarding workplace and community health: how gold mining companies are fighting HIV/AIDS, tuberculosis and malaria*. London, U.K.: World Gold Council [http://www.gold.org/assets/file/pub_archive/pdf/health_mining_full.pdf; accessed: 5 May 2009].

Utzinger J, Wyss K, Moto DD, Yemadji N, Tanner M, Singer BH (2005). *Assessing health impacts of the Chad-Cameroon petroleum development and pipeline project: challenges and a way forward*. Environmental Impact Assessment Review 25: 63-93.

Viliani F, Divall MJ (2007). *Report on scoping survey for health impact assessment: Moto Goldmines Project, Democratic Repoblic of the Congo*. Johannesburg, South Africa: International SOS.

Vohra S (2007). *International perspective on health impact assessment in urban settings*. New South Wales Public Health Bulletin 18: 152-4.

WHO (1986). *The Ottawa Charter for health promotion*. Geneva, Switzerland: World Health Organization.

WHO (2005). *The Bangkok Charter for health promotion in a globalized world*. Geneva, Switzerland: World Health Organization [http://www.who.int/healthpromotion/conferences/6gchp/bangkok_charter/en/; accessed: 5 May 2009].

WHO (2006). *Quantifying environmental health impacts*. Geneva, Switzerland: World Health Organization [http://www.who.int/quantifying_ehimpacts/en/; accessed: 5 May 2009].

WHO (2009a). *Short guides for health impact assessment*. Geneva, Switzerland: World Health Organization [http://www.who.int/hia/about/guides/en/; accessed: 5 May 2009].

WHO (2009b). *Priority interventions: HIV/AIDS prevention, treatment and care in the health sector*. Geneva, Switzerland: World Health Organization [http://www.who.int/hiv/pub/priority_interventions_web.pdf; accessed: 5 May 2009].

Wismar M, Blau J, Ernst K, Figueras J (2007). *The effectiveness of health impact assessment: scope and limitations of supporting decision-making in Europe.* Copenhagen, Sweden: WHO Regional Office Europe [http://www.euro.who.int/informationsources/publications/catalogue/20071015_1; accessed: 5 May 2009].

3. Assessing health impacts in complex eco-epidemiological settings in the humid tropics: the centrality of scoping

Mirko S. Winkler[a,b], Mark J. Divall[c], Gary R. Krieger[d], Marci Z. Balge[d], Burton H. Singer[e], Jürg Utzinger[a,b,*]

[a] Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, P.O. Box, CH-4002 Basel, Switzerland

[b] University of Basel, P.O. Box, CH-4003 Basel, Switzerland

[c] NewFields, LLC, Pretoria 0062, South Africa

[d] NewFields, LLC, Denver, CO 80202, USA

[e] Emerging Pathogens Institute, University of Florida, Gainesville, FL 32610, USA

* Corresponding author. Jürg Utzinger, Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, P.O. Box, CH-4002 Basel, Switzerland. Tel.: +41 61 284-8129; fax: +41 61 284-8105. *E-mail address:* juerg.utzinger@unibas.ch (J. Utzinger).

This article has been published in

Environmental Impact Assessment Review 2011, 31: 310-319

3.1. Abstract

Natural resources development projects are – and have been for more than 150 years – located in remote rural areas in developing countries, where local level data on community health is notoriously scarce. Health impact assessment (HIA) aims at identifying potential negative health consequences of such projects and providing the initial evidence-base for prevention and mitigation of diseases, injuries and risk factors, as well as promotion of positive effects. An important, but under-systematised early phase of the HIA process is scoping. It aims at organising diverse, often fragmentary, evidence and identifying potential project-related health impacts and underlying data gaps. It is also a key element in defining the terms of reference for the entire assessment. We present novel methodological features for the scoping process, emphasising the evaluation of quality of evidence, and illustrate its use in a contemporary HIA of the Simandou iron ore project in the Republic of Guinea. Assessment of data quality is integrated with specific content information via an analytical framework for the systematic identification of health outcomes and determinants of major concern. A subsequent gap analysis is utilised to assess the need for further baseline data collection and to facilitate the specification of a set of potential key performance indicators and strategies to inform the required evidence-base. We argue that scoping also plays a central role in the design of surveillance systems for longitudinal monitoring of health, equity and wellbeing following project implementation.

Keywords: Health impact assessment; Scoping; Developing countries; Iron ore mining project; Republic of Guinea; Baseline health survey.

3.2. Introduction

For more than 150 years, exploration and development of natural resources have frequently been carried out in remote rural areas in tropical countries (Watson, 1921, 1953; Chamberlain, 1929; Boxer, 1962; Manderson, 1996). In contrast to this long history, impact assessments for large-scale development projects are relatively new (IAIA, 2010). Within the impact assessment suite, health impact assessment (HIA) is the most recent addition dating back to the late 1980s/early 1990s, but is increasingly becoming a routine feature of the project permitting and approval processes (Kemm, 2000; Birley, 2003; Mindell and Joffe, 2003). In the developing world, the International Finance Corporation (IFC) has played an important role in this regard through inclusion of community health as a specific performance standard (number 4) (IFC, 2006a). The IFC performance standards are considered the key international benchmarks for the environmental impact assessment (EIA), social impact assessment (SIA) and HIA process (Krieger et al., 2010). In addition, the IFC has issued both guidance notes and a HIA toolkit to ensure that health is fully considered within the overall assessment process (IFC, 2007, 2009a). The World Health Organization (WHO) is in the process of issuing similar guidelines for private sector lenders emphasising the critical role of health in the overall project development process. In addition to IFC, other private sector organisations (e.g. International Petroleum Industry Environmental Conservation Association (IPIECA) and International Council on Mining and Metals (ICMM)) and individual companies (e.g. Chevron, Eni, Newmont Mining and Shell) have developed guidelines and benchmark practices to support HIA within natural resources and industrial development projects (IPIECA, 2005; ICMM, 2010). All of these efforts represent an important step forward towards linking sustainable public health policy with large resource development projects (Mercier, 2003; WHO, 2005; Bos, 2006; Singer and Castro, 2007). Moreover, these initiatives demonstrate an effort to leverage the potential of industrial projects to promote sustainable community health either through direct mitigation of impacts, or through social investment projects (Lerer and Scudder, 1999; WHO, 1999; Utzinger et al., 2004, 2005; The Global Fund, 2008). Voluntary contribution efforts (also known as extended benefits) in the health sector are encouraged, and IFC has developed an overall strategic community investment handbook (IFC, 2010).

However, in many parts of the developing world, the presence of a large-scale development project can severely stress underlying health systems that are already fragile and overwhelmed. Most of the published methodologies for HIA have been developed, validated and applied in Western Europe (Erlanger et al., 2008a). Hence, there is a pressing need to develop 'fit for purpose' HIA methodologies for developing country settings where the inherent resources and available baseline health data are far less sophisticated or unavailable compared to industrialised countries. An important aspect of our ongoing HIA of projects implemented in the humid tropics is to develop and validate appropriate but rigorous tools and methods for the various steps of a HIA (from screening to evaluation). The development of these tools and techniques has largely been driven by empirical necessity, i.e. based on specific case studies. This paper further extends our earlier work pertaining to HIA in complex eco-epidemiological settings (Winkler et al., 2010). Here, we add to the methodology of project scoping for rapid and accurate assessment of available baseline health data, giving particular emphasis to assessments of quality of evidence and combining it with data-driven projections of likely health impacts of the project. We also show how this methodology helps to identify important data gaps, which might require additional baseline health surveys.

Detailed baseline environmental and socio-economic surveys are a regular and well-established feature of the impact assessment process. However, health impacts have repeatedly been identified as inextricably linked to environmental and social impacts as part of EIA and SIA. Exposure to toxic chemicals in communities proximal to mining projects and influx of commercial sex workers, promoting correlative increases in HIV transmission near project construction sites and transportation hubs, are two examples of this phenomenon (Ogola et al., 2002; Clift et al., 2003; Wang, 2004; Laite, 2009). Hence, there is every reason to include human health in analogous baseline analysis and documentation. Private sector companies are largely comfortable with the EIA and the SIA process. However, our experience indicates that in the context of HIA, the private sector is extremely concerned about sliding down a slippery slope that incrementally usurps the appropriate role of the host country's Ministry of Health (MoH). Engaging with the MoH as part of the production of a HIA can dampen this concern. It is in the long-term interest of both resource developer and host country to understand the pre-project health conditions at an appropriate level.

With this background at hand, we proceed in section 2 to explicitly describe the scoping process. Section 3 contains a case study in the mining sector of the Republic of Guinea. In section 4, we spell out our scoping methodology, including gap analysis, emphasising transparency of the components. Utilising our methodology, section 5 contains the key findings from the scoping phase of the aforementioned case study. We conclude in the final section with a discussion of research steps that could further enhance the scoping process.

3.3. Scoping as part of the HIA process

Scoping is an early and important phase of the overall HIA process (Harris et al., 2007; IFC, 2009a). The objective of scoping is to identify the range of potential project-related health impacts, and to ensure that the HIA remains focused on the primary expected outcomes of a project. Scoping provides the blueprint for the entire impact assessment (Mindell et al., 2001; Cole et al., 2005; Joffe and Mindell, 2005).

The increasing number of available HIA guidelines offers a host of techniques and general suggestions for scoping. However, there is no clear articulation about which tools are most suitable for a given context. The complexity of a developing country environment (e.g. broad range of potential health impacts, sensitive socio-cultural issues and human influx concerns), renders the choice of appropriate methods for scoping a formidable challenge. Against this background, we were motivated to develop a specific and rigorous set of strategies, including data quality assessments, for scoping in the context of large-scale development projects operating in complex eco-epidemiological settings.

Our ongoing HIA studies include projects in the mining, water resources development, oil/gas and bioenergy sectors across the globe. Despite the diversity of geography and industrial sectors, there is considerable commonality and typicality in the scoping issues that are encountered. The generic scoping process will be presented in the context of a HIA for a large iron ore mining project in West Africa (Rio Tinto, 2010). We highlight the centrality of scoping for planning of the next steps of the HIA process (e.g. whether or not collection of additional baseline health data is necessary). Indeed, scoping is essential for determining the health status of project-affected communities and enabling long-term monitoring of project-related health impacts.

3.4. Case study

3.4.1. General considerations

In the Republic of Guinea, the mining sector contributes approximately 20% of the gross domestic product (GDP) and over 70% of export revenues (IFC, 2006b; CIA, 2009). Many of the poorest people in the Republic of Guinea are resident in the eastern part of the country. Thus, any large-scale economic activity in this part has the potential to both positively and negatively impact health, equity and wellbeing of potentially affected communities (PACs).

3.4.2. Rio Tinto Simandou project

The Rio Tinto Simandou project is an iron ore exploration and mining project located in the south-eastern part of the Republic of Guinea (Figure 3.1). Rio Tinto's presence in the country dates back to 1997, accompanied by initial exploration work at Simandou, a 110-km long mountain range at an altitude up to 1,650 m above sea level. In 2003, Rio Tinto signed a mining convention with the government of the Republic of Guinea to develop a mining concession at Simandou, including a 700-km long heavy haul iron ore railway and a deep-water port south of Conakry. The total workforce has been predicted to exceed 10,000 people for the construction of the mine, rail and water port, with some 4,500 full-time jobs during the project's operational phase. At an estimated production rate of over 70 million tonnes per annum over a 50-year period, the Simandou mine is predicted to generate considerable taxes and royalties to the Government of the Republic of Guinea, and contribute to a regional development fund (Rio Tinto, 2010).

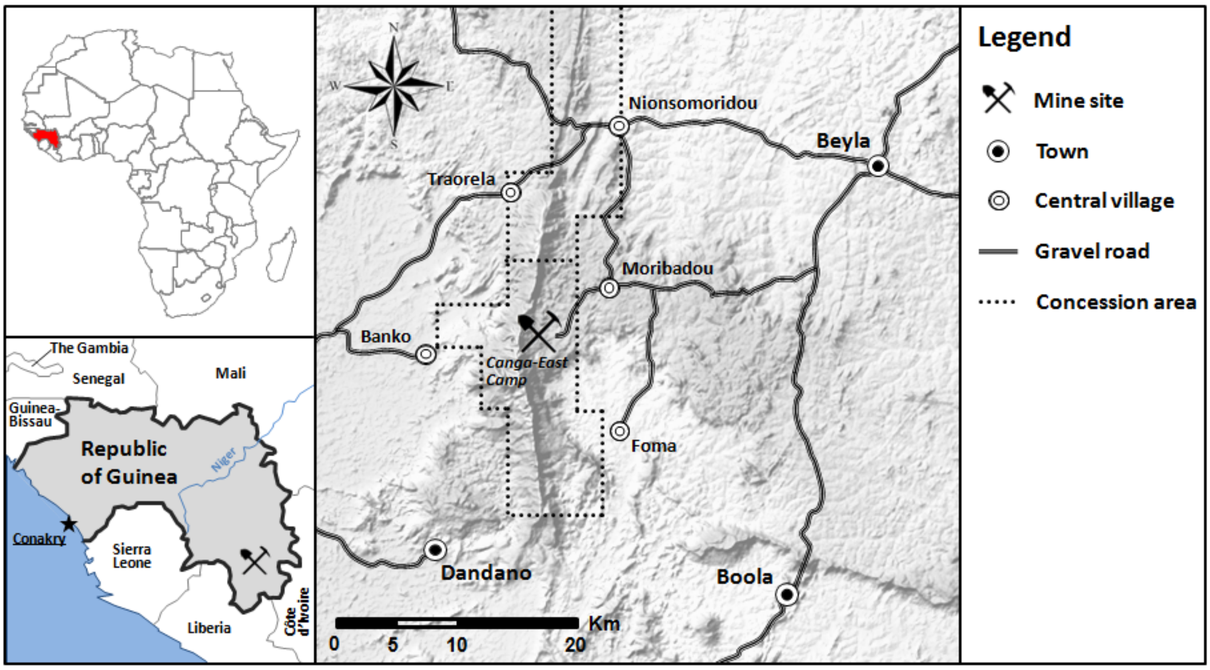


Figure 3.1: Map showing the location of the Rio Tinto Simandou project in south-eastern Republic of Guinea and the surrounding communities (background: shaded relief map).

3.4.3. Corporate objectives and standards

Rio Tinto has a group community relations standard that serves as a framework for each operation to develop its own community relations policy. Additionally, the company has published a statement of business practice entitled "The way we work", with the stated goal to support regional- and community-based projects that contribute to sustainable development, without creating dependency (Rio Tinto, 2010). IFC is a partner in the Simandou project, holding a share of 5%. Thus, Rio Tinto must adhere to 'IFC social and environmental sustainability performance standards' (including community health) for the Simandou project (IFC, 2006a). Strategic community investment is also an important consideration, particularly since most health programmes are dual-use, i.e. a health mitigation programme often has extended benefits to a wider set of communities than those in close proximity to the project (Utzinger et al., 2004; IFC, 2010). Consistent with IFC and corporate standards, a HIA of the proposed project was commissioned with a formal, detailed community health management plan (CHMP) as an ultimate deliverable and management tool.

3.5. HIA scoping study: methodology and gap analysis

3.5.1. Guiding framework

In 2009 the IFC released a HIA toolkit (IFC, 2009a) that outlines a methodology to support the requirements of performance standard number 4 (IFC, 2006a) and guidance note number 4 (IFC, 2007), which pertain to community health, safety and security. The proposed HIA framework for the Simandou project was developed in accordance with these IFC standards and guidance note. Tools such as the environmental health areas (EHAs) framework, stratification of the relevant population into PACs and a risk analysis matrix to facilitate ranking of potential health impacts for subsequent prioritisation of mitigation strategies form an integral part of the assessment, and are described in more detail elsewhere (Winkler et al., 2010).

For the Simandou project, the need to consider community health was identified during the preliminary social assessments (La Granada Enterprise, 2008; SNC-Lavalin, 2009). The size of the potential area of influence of the proposed project, a high social sensitivity of the local communities, and a broad range of potential project-related health impacts triggered the need for a comprehensive HIA (IFC, 2009a). Against this background, the HIA screening concluded that a HIA is necessary, and hence a detailed scoping phase was deemed essential. The scoping analysis would set the boundaries of the HIA, and further clarify the following issues:

- timing and geographical boundaries;
- PACs, including the identification of inequalities and most vulnerable groups;
- baseline health status of the affected people, stratified by PACs;
- high-level health impacts and health needs, stratified by PACs;
- gaps that may exist in the baseline health data of the PACs;
- key performance indicators (KPIs) for subsequent monitoring and evaluation of the HIA and any CHMP and their outcomes;
- key stakeholders of the HIA, including their roles and responsibilities;
- non-governmental organization (NGO) partners that could support health initiatives in communities through assistance programmes; and
- overall scope, methodology and terms of reference (ToR) for the HIA.

In developing countries – where a broad range of health concerns and considerable local variation is the rule rather than the exception – it is crucial to have reliable evidence on the health status of affected communities in order to perform an effective impact assessment. This assessment prioritises potential impacts and leads to the development of a suite of relevant mitigation management measures. In order to effectively develop cost-effective mitigation strategies, it is essential to have robust KPIs for subsequent monitoring and surveillance for the selected mitigation activities. Hence, the identification of available information on the baseline health status of PACs becomes a challenging task that draws on (i) existing project documents (e.g. any available local, regional or national socio-economic studies) as well as peer-reviewed and grey literature (e.g. any national demographic and health surveys (DHS), WHO data, Multiple Indicator Cluster Surveys (MICS) of the United Nations Children's Fund (UNICEF) and research-driven epidemiological investigations) and (ii) available health statistics from local health facilities. Socio-economic data are critical as extensive published literature demonstrates that key health outcomes strongly covary with income/consumption expenditure, employment status, educational attainment of the household head, female educational attainment, household consumer durable assets and other physical capital indicators such as housing characteristics, size/occupancy rates and housing construction materials, water sources and distances, etc. (Wagstaff et al., 1991; Gwatkin et al., 2000; Filmer and Pritchett, 2001; O'Donnell et al., 2008). Baseline health analysis can be facilitated by understanding the intimate connection between key physical, financial and education "capitals" and health. While education is typically included with health under "human capital" (Moser, 1998), our experience indicates that household educational attainment is much simpler to obtain than reliable community morbidity and mortality data. All of this analysis helps identify data gaps within the PACs. The capital analysis is a central feature of our scoping study approach as it cost-effectively develops a picture of the PACs and focuses attention on those data gaps that need to be filled by additional household-level field assessments.

3.5.2. Initial literature review

Project-related data included an initial review of the present preliminary project designs and proposed activities, the potential zones of influence and the location of people/communities in relation to these, past social and environmental baselines and assessments, community health interventions and any other related documentation. This included the socio-economic baseline studies that were conducted in the project area in 2008, which provided valuable background information on the project area in general and detailed community profiles that could be analysed in terms of key health covariates (La Granada Enterprise, 2008; SNC-Lavalin, 2009). Company management standards and policies were also consulted.

To further inform the baseline status in the area of influence, a literature review was carried out to profile the health status of the communities residing in the footprint of the Simandou project, which was done prior to a first field visit. Due to the unstable political situation in the country, there has been a paucity of health-related research in the Republic of Guinea over the past decade. Information that was available often excluded remote regions of the country. Thus, minimal current health-related publications could be identified in the peer-reviewed literature, and none had a specific focus on the project area. Nevertheless, approximately 40 sources (mainly grey literature) were identified, from which data could be extracted to profile the baseline health status. Of note, identified sources from WHO, UNICEF, United States Agency for International Development (USAID), Food and Agriculture Organization (FAO) only provided disease prevalence rates on a national level and occasionally at a regional level, but not at a local level.

Of particular relevance was the 2005 Guinea DHS (GDHS) ((Direction Nationale de la Statistique (DNS) and ORC Macro, 2006) which provided a host of demographic and health-specific indicators, stratified on a regional level. The 2005 GDHS was the third of its kind conducted in the Republic of Guinea and allowed comparison with the two previous GDHS done in 1992 and 1999 for analyses of trends. An additional key source was the provisional report on the National Survey on the Nutritional Status and Key Indicators of Child Survival (NSCS) (DNS, 2008), which was carried out as direct follow-up of the 2005 GDHS. The goal of this survey was to obtain reliable information to define appropriate interventions to reduce the upward trend in child malnutrition that was observed in the GDHS.

As part of the standard process of getting stakeholder involvement, the initial literature review formed the basis for production of a set of interview guides to support key informant interviews (KIIs) in a subsequent field visit. The interview guides were based on the structure of the EHAs and comprised a set of open-ended questions to deepen the understanding of community baseline health status in the project area. Similarly, discussion guides can be prepared to carry out a limited number of focus group discussions (FGDs) with community members to determine local knowledge, attitude and practices (KAP) regarding specific health-related issues. However, in the present scoping study no further FGDs were conducted, since health-related information at the community level, using various qualitative and quantitative methods, had already been obtained as part of the previously conducted socio-economic baseline studies (La Granada Enterprise, 2008; SNC-Lavalin, 2009).

3.5.3. Field visit and stakeholder engagement

Stakeholder engagement is a foundation of the HIA process. In the scoping stage, it is essential to engage the national and prefecture health authorities and administrators, key local actors in the health and social development sectors, as well as village leadership structures. Our experiences thus far with engaging different stakeholders are that "top-down" engagement is essential prior to local interactions. In many projects the desire to have "bottom-up" dialogue often overlooks the essential need to involve senior MoH officials prior to extensive community-level engagement.

Key areas of support and potential collaborations were discussed with the MoH in Conakry, which led to the formal authorisation from the MoH in the form of an "Ordre de Mission" for the planned scoping activities. This document, in turn, facilitated engagement with the health authorities in Beyla to obtain permission for a meeting with the decentralised health centres and posts, and allowed us to have access to readily available health statistics at the Beyla prefecture.

Communities residing on the perimeter of the project were visited. This included a visit to the district hospital in Beyla, the health centres in Nionsomoridou and Boola, the health post in Moribadou, as well as the Simandou project medical centre (Fig. 1). KIIs were done with health professionals, adhering to the previously elaborated and pre-tested interview guide.
Taken together, a variety of (i) project documents, (ii) local and regional health statistics, (iii) national public health programme policies, (iv) information on local NGOs engaged in health, including other stakeholder agencies that were active in the project area, and (v) other potential partners for community health were interviewed during the field visit. The information and knowledge derived from these documents and interviews were then

incorporated into the EHAs framework to form a detailed baseline demographic, health and socio-economic profile of the PACs.

3.5.4. Health outcomes and determinants of major concern

The accumulated baseline health data obtained from the initial literature review and the in-country field visit were analysed in order to accurately frame the overall scope and determine any relevant data gaps. It is of pivotal importance during this early stage to focus the impact assessment on the most important health issues; a necessity in view of the multi-factorial settings that are commonly encountered in a developing country context.

As an entry point, the occurrence and importance of the different health outcomes and determinants were assessed for the project region, drawing on the available evidence, including: (i) peer-reviewed and grey literature, (ii) stakeholder input, including information obtained from KIIs and FGDs, and (iii) direct observations made during field visits (Figure 3.2). Such a methodological triangulation, leading to multiple forms of evidence and perspectives, is an important means to enhance the validity of a decision and thus most relevant for the entire HIA (Razum and Gerhardus, 1999). Hence, the different sources were checked against the others to finally summarise and stratify the health outcomes and determinants. We employed the following system: (i) absent (e.g. dracunculiasis has been eliminated in the Republic of Guinea), (ii) rare/insignificant (e.g. very few cases of human African trypanosomiasis (HAT) were reported for the project region), (iii) occasional/minor importance (e.g. skin diseases and diabetes), and (iv) frequent/major importance (e.g. malaria and diarrhoeal diseases).

In a second step, with the detailed analysis of each EHA, it was determined, which of the health outcomes and determinants were of major concern from a public health perspective and in view of potential future project-related health impacts. In this process, it is important to consider community, project and institutional risk factors, which are often interlinked. For example, the high endemicity of malaria in the project area is a risk factor for the workforce be they recruited locally or from further away. This is also influenced by the presence or absence of institutional capacities (e.g. existence of a functional national malaria control programme).

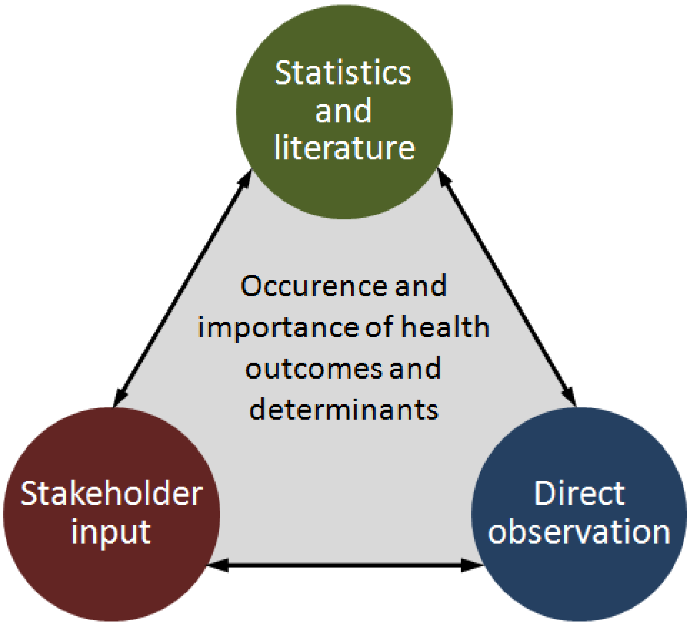


Figure 3.2: Methodological triangulation to determine the occurrence and importance of health outcomes and determinants.

As a result, the selection process was based on the analysis of available evidence, best professional judgement, and further consolidated by means of a modified Delphi approach (Rowe and Wright, 1999). Provision of a rationale for the 'best professional judgements' by the assessors themselves can provide a level of transparency for the results that can be challenged by critics and, in an iterative process, even revised.

3.5.5. Gap analysis

A gap analysis informs the assessors whether sufficient data are available to proceed directly with the risk/impact analysis and mitigation phase, or, in case of inadequate or insufficient data, whether the collection of additional baseline health data is recommended. Figure 3.3 shows a decision-tree, which is used to support the decision-making process on whether or not additional baseline health data collection is necessary to support the overall HIA framework (IPIECA, 2005; IFC, 2009a).

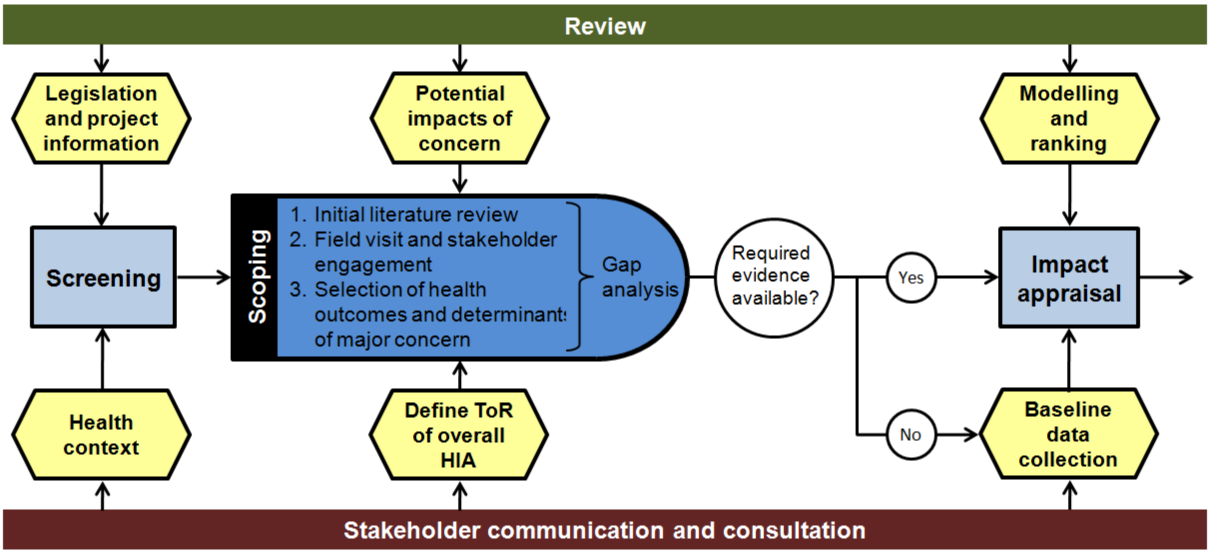


Figure 3.3: The evidence gathering and decision-making process of scoping to support the overall HIA (adapted from IPIECA (2005) and IFC (2009a)).

In practice, a gap analysis has a focus on the health outcomes and determinants of major concern that were defined in the prior data collection and information gathering. This includes critical appraisal of data quality of identified sources. While information from national surveys such as the GDHS, the NSCS or peer-reviewed literature usually provide robust data, the accuracy of grey literature or routine health facility statistics needs to be scrutinised in greater depth. Importantly, data on major health outcomes and determinants of concern require a high level of accuracy on a regional and/or local level allowing for evidence-based risk and impact assessment and subsequent monitoring and surveillance. Based on these requirements, the available quantitative and qualitative information was ranked as follows: (i) low level of fidelity, (ii) moderate level of fidelity, and (iii) high level of fidelity.

In case important data gaps are identified, additional baseline data collection becomes part of the ToR for the overall HIA. This includes further specifications of KPIs to inform the required evidence-base. Two major strategies are available to support this collection of primary data. The first is to perform a baseline health survey in the project region. This can entail the collection of qualitative and quantitative data to produce representative KPIs that can be utilised to monitor mitigation and management strategies. The primary data collection methods can be based on a variety of methods such as examination of biological samples (e.g. blood, sputum, stool and urine), anthropometric measures (e.g. height, weight, blood pressure and arm circumference), questionnaires, observations (e.g. presence of latrines and sleeping under an insecticide-treated net (ITN)), FGDs, in-depth interviews and environmental monitoring, among others. The second is referred to as health system strengthening by reinforcing the diagnostic accuracy and reporting systems of the local health facilities. This is not only an important means to obtain longitudinal data, but also the preferred strategy for indicators that are difficult to assess in a cross-sectional study (e.g. incidence of respiratory disease and number of traffic accidents). Additionally, the reinforcement of diagnostic accuracy also has great potential to have a positive impact on community health and can thus become a community health intervention *per se* (e.g. provision of rapid diagnostic tests (RDTs) for malaria diagnosis) (D'Acremont et al., 2009).

3.6. Key findings from HIA scoping study

To illustrate the analytical framework of our scoping methodology, the evaluation of two specific EHAs (i.e. EHA 2: vector-related diseases; EHA 3: soil-, water- and waste-related diseases) will serve as examples. Table 3.1 provides a comprehensive overview of the key findings and conclusions derived from the entire scoping process. This level of detail, including the assessment of data quality, is rarely – if ever – included as part of scoping in the HIA. However, this form of reporting greatly enhances the utility of the scoping analysis and provides stakeholders with a better understanding of how the overall conclusions were reached.

Table 3.1: Summary table of health outcomes and determinants of major concern, and their inclusion in additional baseline data collection.

No.	Environmental health areas (EHAs) / Health outcomes and determinants	Most important data sources at regional and local level	Occurrence/ importance	Health outcome/ determinant of major concern	Pooled quality ranking of available evidence	Additional baseline data needed	Source of additional baseline data
1	Communicable diseases						
	Tuberculosis	HFS	♦♦♦	x	♦	x	HSS
	Respiratory tract infections	HFS	♦♦♦	x	♦♦	x	HSS
	Measles	HFS	♦				
	Meningitis	HFS	♦				
	Leprosy	HFS	♦				
2	Vector-related diseases						
	Malaria	HFS, GDHS, NSCS	♦♦♦	x	♦	x	BHS, HSS
	Arboviral diseases	HFS	♦				
	Human African trypanosomiasis (HAT)	HFS	♦				
	Lymphatic filariasis	HFS	♦				
	Dracunculiasis	ND	–				
3	Soil-, water- and waste-related diseases						
	Diarrhoeal diseases	HFS, GDHS, NSCS	♦♦♦	x	♦♦	x	BHS, HSS
	Soil-transmitted helminthiasis	HFS	♦♦♦	x	♦♦	x	BHS
	Schistosomiasis	HFS	♦♦♦	x	♦	x	BHS
	Buruli ulcer	HFS	♦				
	Hepatitis A and E	n/a					
4	Sexually-transmitted infections (STIs), including HIV/AIDS						
	HIV/AIDS	GDHS, HFS, BS	♦♦♦	x	♦♦	x	BHS, HSS
	STIs	GDHS, HFS, BS	♦♦♦	x	♦♦	x	BHS, HSS
	Hepatitis B	n/a					

No.	Environmental health areas (EHAs) / Health outcomes and determinants	Most important data sources at regional and local level	Occurrence/ importance	Health outcome/ determinant of major concern	Pooled quality ranking of available evidence	Additional baseline data needed	Source of additional baseline data
5	Food- and nutrition-related issues						
	Malnutrition	HFS, GDHS, NSCS	♦♦♦	x	♦♦	x	BHS, HSS
	Anaemia	HFS, GDHS, NSCS	♦♦♦	x	♦♦	x	BHS
6	Non-communicable diseases						
	Cardiovascular diseases	HFS	♦♦	x	♦	x	BHS, HSS
	Diabetes mellitus	n/a					HSS
	Cancer	HFS	♦♦				
	Chronic respiratory diseases	HFS	♦♦				
7	Accidents/injuries						
	Traffic accidents	HFS	♦♦	x		x	HSS
	Work-related injuries	HFS	♦				
8	Veterinary medicine and zoonotic diseases						
	Leptospirosis	n/a					
	Rabies	n/a					
	Lassa fever	ND	♦				
9	Exposure to potentially hazardous materials, noise and malodours						
	Water quality	EIA	♦♦♦	x	♦♦	x	BHS, EnvM
	Air quality	EIA	♦♦	x	♦	x	EnvM
	Noise	EIA	♦♦	x	♦	x	EnvM
	Waste management	EIA	♦♦	x	♦♦		BHS, EnvM

No.	Environmental health areas (EHAs) / Health outcomes and determinants	Most important data sources at regional and local level	Occurrence/ importance	Health outcome/ determinant of major concern	Pooled quality ranking of available evidence	Additional baseline data needed	Source of additional baseline data
10	Social determinants of health						
	Mental health	HFS	♦♦	x	♦	x	BHS, HSS
	Health seeking behaviours		♦♦♦	x	♦	x	BHS, HSS
	Life style	SIA	♦♦	x	♦♦	x	BHS
	Inequalities	SIA	♦♦♦	x	♦♦	x	BHS
	Health education	GDHS, SIA	♦♦♦	x	♦	x	BHS
11	Cultural health practices						
	Traditional medicine	GDHS, SIA	♦♦♦	x	♦	x	BHS
	Female circumcision	GDHS	♦♦♦				
12	Health systems issues						
	Infrastructure and capacity	ND	♦♦♦	x	♦♦	x	BHS
	Reproductive health	GDHS	♦♦				
	Maternal health	HFS, GDHS, NSCS	♦♦♦	x	♦♦	x	BHS, HSS
	Child health and immunization	HFS, GDHS, NSCS	♦♦♦	x	♦♦	x	BHS, HSS
	Programme management and delivery systems		♦♦♦	x	♦♦♦		

Abbreviations: BHS, baseline health survey; BS, baseline study; EIA, environmental impact assessment; EnvM, environmental monitoring; GDHS, Guinea Demographic and Health Survey; HFS, health facility statistics; HSS, health system strengthening; n/a, not applicable; ND, national data; NSCS, National Survey on the Nutritional Status and Key Indicators of Child Survival; SIA, social impact assessment

Occurrence/importance: –, absent; ♦, rare/insignificant; ♦♦, occasional/minor importance; ♦♦♦, frequent/major importance.

Health outcome/ determinant of major concern; Additional baseline data needed: x, applies.

Pooled quality ranking of available evidence: ♦ low level of fidelity; ♦♦ moderate level of fidelity; ♦♦♦ high level of fidelity

3.6.1. EHA 2: vector-related diseases

In the initial literature review, malaria (RBM, 2010), arboviral diseases (i.e. yellow fever and dengue) (CDC, 2009; WHO, 2009), HAT (Simarro et al., 2008) and lymphatic filariasis (GAELF, 2008) were identified as vector-related diseases that occur in the Republic of Guinea. Clearly, malaria was identified as the single most important vector-related disease in the project area, whereas none of the other potential vector-related diseases were mentioned by key informants or reported in health statistics obtained during the in-country field visits.

According to the GDHS 2005, which provides robust information on the use of preventive measures against malaria down to a regional level, the national malaria prevalence was 18% for the entire population and 21% among pregnant women in 2002 (DNS and ORC Macro, 2006). Local level statistics on malaria morbidity were obtained during the in-country field visit. In 2007, out of 56,762 registered consultations in Beyla prefecture, 13,537 (23.9%) were diagnosed for malaria (all age groups), with 5180 of the patients aged 5 years and below (Service National d'Information Sanitaire (SNIS), 2007). Also in the first term of 2008, one in four patients presented with malaria in Beyla prefecture (SNIS, 2008). The KIIs with local health authorities and professionals of the health facilities in proximity to the project underscored that malaria is a key public health problem. Interestingly though, questions pertaining to local practices regarding vector control measures, as well as direct observations, revealed a less homogeneous picture, indicating considerable variation in the perceived public health relevance of malaria among local communities.

We concluded that malaria is a disease of major importance in the project area and a key community risk factor. The Simandou project represents a possible additional risk factor for malaria as it will result in demographic and environmental transformations linked to in-migration and project-related environmental changes that may, or may not, expand the *Anopheles* larval habitats. Health systems performance, or the lack thereof, is considered as an institutional risk factor for the heavy burden of vector-related disease, which is further reflected by the fact that only one out of five households in the N'Zérékoré region were in possession of an ITN at the time of the NSCS carried out in 2007 (DNS, 2008). Malaria is thus clearly a major health outcome of concern for the HIA that will need special attention.

Although the GDHS and the NSCS provide regional data on the possession and use of two preventive measures against malaria (i.e. ITNs and intermittent preventive treatment during pregnancy (IPT_p)), little is known regarding local variation. Additionally, the true malaria prevalence in the project region is unknown due to the lack of community-based malaria surveys. This is also true for people's KAP of vector control measures in the local communities. Ultimately, the accuracy of available morbidity statistics is reduced as peripheral health facilities in the study area rely on presumptive diagnosis due to the lack of microscopes and RDTs. In conclusion, the available information on malaria and its determinants has a low level of fidelity and considerable data gaps exist. Clearly, further baseline data on a local level will be required, not only to deepen the understanding of the malaria burden in the project area at an early project stage, but also to further our understanding of local KAP in relation to vector-related disease and prevention. Potential KPIs and strategies to inform the required evidence-base are presented in Table 3.2.

Table 3.2: Potential key performance indicators (KPIs) and strategies to inform the required evidence-base on vector-related diseases (EHA 2).

Baseline health survey:

- Malaria prevalence in children below the age of 5 years (The Global Fund, 2009)
- Percentage of children with a measured haemoglobin concentration of less than 8 g/dl (The Global Fund, 2009)
- Percentage of children below the age of 5 years that sleep under an insecticide-treated net (ITN) (MEASURE DHS, 2010)
- Percentage of women who received two or more doses of intermittent preventive treatment (IPT) for malaria during their last pregnancy (MEASURE DHS, 2010)
- Status of knowledge, attitude and practices (KAP) in relation to malaria and how to prevent the disease

Health system strengthening:

- Longitudinal data on malaria incidence by improving diagnostic and reporting abilities of the local health facilities

3.6.2. EHA 3: soil-, water- and waste-related diseases

In 2006, it was estimated that 51-75% of the Guinean population is using an improved drinking water source, but less than 25% used improved sanitation facilities such as latrines (WHO/UNICEF, 2008). For the project region, the socio-economic baseline study (La Granada Enterprise, 2008) reported that, on average, less than 60% of the population had access to improved drinking water sources in 2008 and most of the population relied on unprotected surface water from local rivers, streams and other freshwater bodies in close proximity to villages. According to the NSCS, over 50% of the households in the N'Zérékoré region practiced open defecating, which represents the highest portion of any region in Guinea (DNS, 2008). As a result, diarrhoeal diseases are a major public health concern in Guinea with 16% of children under the age of 5 years who had at least one episode of diarrhoea during the 2 weeks before health interviews were conducted by GDHS (DNS and ORC Macro, 2006). This rate was highest in N'Zérékoré region (21.6%).

According to health statistics of Beyla prefecture with 56,762 registered consultations in 2007, common diarrhoea was responsible for 7.5% of all the consultations (n = 4,263; all age groups). There were 2,451 cases with bloody diarrhoea, accounting for 4.3% of the total number of consultations (SNIS, 2007). In the immediate project area, diarrhoea is one of the most important causes of morbidity in the local communities. In 2008, at Nionsomoridou and Boola health centres, 21.7% and 33.8% of all diarrhoeal cases (*n* = 106 and *n* = 284; all age groups) were bloody diarrhoea, respectively. There is a host of bacterial, viral and parasitic agents as potential causes for common diarrhoea in the project region, most of which are spread by faeces-contaminated water. However, there is a lack of diagnostic tests at the community health facilities, and hence the aetiology of diarrhoea warrants further investigation.

In 2007, helminthiasis was the third leading cause of health seeking according to statistics at Beyla prefecture, accounting for 14% (*n* = 7,962) of the total consultations (SNIS, 2007). The 2008 health statistics of Nionsomoridou and Boola health centres revealed that soil-transmitted helminth (STH) infections ranked fourth (*n* = 464) and third (*n* = 81) in terms of consultations, respectively. Few cases of intestinal schistosomiasis due to *Schistosoma mansoni* and urinary schistosomiasis due to *Schistosoma haematobium* were reported for Beyla prefecture in 2007; they accounted for 1.5% (n = 834) and 0.3% (n = 194) of the total number of health consultations, respectively (SNIS, 2007).

In view of the many community risk factors, such as unsafe drinking water, lack of sanitation facilities and poor hygiene, it is conceivable that soil-, water- and waste-related diseases are highly prevalent. Indeed, available health statistics and KIIs reveal high frequencies of diarrhoeal diseases and STH infections, whereas schistosomiasis was of lesser importance.

However, visits to the local health facilities revealed that the diagnosis of STH and schistosome infections was based on a syndromic approach, and hence the data have to be interpreted with care. Awareness about the transmission of helminthiases and how to prevent these parasitic worm infections was limited. The Simandou project, which is likely to trigger substantial in-migration into the project area (La Granada Enterprise, 2008; IFC, 2009b), represents an additional risk factor, as it may induce further pressure on the already limited clean water and sanitation infrastructure. Concluding, diarrhoeal diseases and STH infections are health outcomes of major concern for the HIA. Importantly, the Simandou project supports water and sanitation services and was indeed the only such capacity enhancement identified during our scoping survey. Hence, it is conceivable that diarrhoeal diseases and helminth infections are mitigated by the project.

The currently available data on soil-, water- and waste-related diseases, which are based on syndromic approaches, have a low to moderate fidelity due to the lack of standardised, quality-controlled copro-microscopic diagnoses. Consequently, this jeopardises proper prioritisation of mitigation strategies as well as any future monitoring and surveillance activities. KPIs identified to tackle the gap between available and required information on EHA 3 are presented in Table 3.3.

Table 3.3: Potential key performance indicators (KPIs) and strategies to inform the required evidence-base on soil-, water- and waste-related diseases (EHA 3).

Baseline health survey:

- Percentage of households that have functioning improved toilet facilities within their compounds (Finn, 2007)
- Water quality of community water sources
- Water quality ‘in the glass’ at household level
- Prevalence and intensity of soil-transmitted helminth and schistosome infections in school-aged children (Hall and Horton, 2008)
- Status of knowledge, attitude and practices (KAP) in relation to water and sanitation practices as well as personal hygiene

Health system strengthening:

- Longitudinal data on diarrhoeal disease, soil-transmitted helminthiases and schistosomiasis by improving diagnostic and reporting abilities of the local health facilities

3.7. Discussion

Scoping is the second step in the overall HIA process and plays a crucial role in subsequent phases of risk appraisal, mitigation and long-term monitoring (Cole et al., 2005; Joffe and Mindell, 2005; Harris et al., 2007). The results of the scoping process often constitute the *de facto* evidence source for the HIA. This is particularly the case when there are financial constraints and severe time restrictions – several days to a few weeks – on carrying out the entire HIA process, as for example in the Nam Theun 2 hydroelectric project in Lao People's Democratic Republic (Lao PDR) (Krieger et al., 2008). Much more extensive baseline data than was used in the official HIA were in fact available via the MoH in Lao PDR. They were only organised and published after completion of the HIA due to the time constraints imposed on the HIA process for that project (Erlanger et al., 2008b; Sayasone et al., 2009).

In this regard, an important consideration is the availability and quality of different data sources that have been identified and carefully reviewed within the scoping exercise (Bhatia and Seto, 2010). While national surveys such as DHS and MICS provide relevant data at the regional level, they often lack precision at a smaller scale (district and village level). Indeed, health characteristics and potential project-related impacts often vary considerably from one community to another, and hence local-level health data is crucial. Health statistics are often the only available data source at this fine-grained level, but data quality might be an issue. In a first instance, it is important to know which methods and diagnostic approaches were utilised to determine the presence of malaria, intestinal parasites, sexually-transmitted infections (STIs) and non-communicable disease. Moreover, data management and reporting needs to be scrutinised. Accessibility and affordability of health care are other important factors to be considered as they have important repercussions on the local validity and representativeness of health facility statistics (Rowe et al., 2009). Hence, critical appraisal of data quality of identified sources plays an important role and governs the subsequent gap analysis. The appraisals must, of necessity, be condition/disease-specific. For example, in a specific setting all the health facilities may be equipped with RDTs for malaria, while diagnosis of intestinal parasite infections relies on clinical algorithms that lack accuracy, and hence lead to different levels of data quality reported in the same health facility-based statistics. Malaria diagnostic data would receive a high quality rating, whereas data on diagnosis of intestinal parasites would be assigned a lower quality grade. The scoring of data quality is also closely related to the importance of the relevant health issue, which is of particular interest with regard to subsequent monitoring and surveillance of major potential health impacts.

In the developing world, the broad range of potential health impacts, sensitive socio-cultural and equity issues, and human influx concerns are often the driving forces in the HIA process for large-scale development projects. In case important data gaps are identified during the scoping process, or the project operates in a setting with a high social sensitivity, has a broad range of potential health impacts, or a large footprint, then more comprehensive HIA should be the preferred mode of assessment, which means that in-country data gathering is required (Harris et al., 2007; IFC, 2009a). The key point here is that the overall financial envelope and the possible short time frame allotted for the full HIA are important limiting factors. As HIA become a more routinised part of the planning process for development projects in the tropics, we would anticipate longer allowed time periods for their conduct. As they parallel EIA and/or SIA, or are even integrated with them, major data gaps identified in the scoping process are more likely to be filled.

With this background at hand, it is important to embrace a forward looking perspective for a durable implementation of the HIA process, justified as follows. First, the selective stakeholder engagement and limited community involvement in this initial phase reduces costs and the risk of survey fatigue, enables coordination with other impact assessment teams for joint data collection and promotes critical stakeholder input at the initiation of the project. Second, the orientation of the impact assessment process on a selected number of health outcomes and determinants of major concern allows focusing of the HIA on the essential variables from evidence-based considerations. Third, the structured analytical framework puts the assessors in a position where they can face the challenging task of developing a comprehensive study design for a baseline health survey that is (i) oriented towards the required outcomes, (ii) adapted to the local context, and (iii) facilitates local and national health authority engagement. The scoping study methodology presented here is applicable to different levels of a HIA. It may also lead to the conclusion that no additional data collection is required. However, what is the value of HIA in developing countries without the monitoring of future project-related health impacts and community development programmes? Epidemiological data allows the proponent to measure, and thus monitor health impacts and outcomes accurately. At the same time, there are many health-related indicators that go beyond health *per se* and allow characterisation of general wellbeing, vulnerability and resilience of entire communities (e.g. malnutrition and access to health care, clean water and adequate sanitation). The potential of epidemiological indicators must be emphasised as it is a promising way to monitor the return on social investment programmes.

3.8. Conclusion and outlook

Scoping is a rapid-appraisal process that uses information of varying quality from diverse sources enroute to providing a synthesis of the likely routes to project-related health impacts and a distillation of baseline data. Despite the central importance of this phase in the overall HIA process, and the fact that in some instances it serves as the HIA itself, reporting of scoping results has been remarkably informal and lacking in transparency about the rationale behind critical judgements made by assessors. As the demand for, and scrutiny of, HIA increase, there will be a growing need for a more structured scoping process than heretofore.

We have presented details of a systematic scoping methodology and reporting framework with illustration of its implementation for a mining project in the Republic of Guinea. Although the details of the findings are project-specific, the systematic structure is generic for scoping. The evidence-based selection of major health outcomes and determinants of major concern, including quality assessment of data/information sources and explication of rationale for 'best professional judgements' is an innovation of our methodology that enhances the transparency of the scoping process.

3.9. Acknowledgements

We thank Frédéric Chenais and Catherine Garcia from Rio Tinto Simandou project for the constructive collaboration, Dr. Mohamed Lamine Magassouba of the Clinique Ambroise Paré in Conakry and Aicha Camara from the community relations team for their great assistance prior to, and during the field visit, Dr. Sandounou Dimitriou from the Guinean MoH for his kind support and interest, and the staff of the local health facilities for their time and commitment. Mirko S. Winkler is grateful to NewFields for a PhD fellowship.

3.10. References

Bhatia R, Seto E (2010). *Quantitative estimation in Health Impact Assessment: opportunities and challenges*. Environmental Impact Assessment Review 31: 301-309.

Birley M (2003). *Health impact assessment, integration and critical appraisal*. Impact Assessment and Project Appraisal 21: 313-312.

Bos R (2006). *Health impact assessment and health promotion*. Bulletin of the World Health Organization 84: 914-915.

Boxer C (1962). *The golden age of Brazil: growing pains of a colonial society 1695-1750*. Manchester, U.K.: Carcanet Press.

CDC (2009). *Division of vector-borne infectious disease: denguedFever*. Atlanta, Georgia, U.S.: Centers for Disease Control and Prevention [http://www.cdc.gov/ncidod/dvbid/dengue/; accessed: 5 January 2011].

Chamberlain WP (1929). *Twenty-five years of American medical activity on the Isthmus of Panama 1904-1929: a triumph of preventive medicine*. Mount Hope, Trinidad and Tobago: The Panama Canal Press.

CIA (2009). *The world fact book: Guinea*. Washington, D.C., U.S.: Central Intelligence Agency [https://www.cia.gov/library/publications/the-world-factbook/geos/gv.html; accessed: 5 January 2011].

Clift S, Anemona A, Watson-Jones D, Kanga Z, Ndeki L, Changalucha J, Gavyole A, Ross DA (2003). *Variations of HIV and STI prevalences within communities neighbouring new goldmines in Tanzania: importance for intervention design*. Sexually Transmitted Infections 79: 307-312.

Cole BL, Shimkhada R, Fielding JE, Kominski G, Morgenstern H (2005). *Methodologies for realizing the potential of health impact assessment*. American Journal of Preventive Medicine 28: 382-389.

D'Acremont V, Lengeler C, Mshinda H, Mtasiwa D, Tanner M, Genton B (2009). *Time to move from presumptive malaria treatment to laboratory-confirmed diagnosis and treatment in African children with fever*. PloS Medicine 6: 4-6.

DNS (2008). *Enquête nationale sur l'état nutritionnel et le suivi des principaux indicateurs de survie de l'enfant (rapport provisoire)*. Conakry, Republic of Guinea: Direction Nationale de la Statistique.

DNS, ORC Macro (2006). *Enquête démographique et de santé, Guinée 2005*. Claverton, Maryland, U.S.: Direction Nationale de la Statistique (Guinée) and ORC Macro.

[http://www.measuredhs.com/pubs/pdf/FR162/FR162-GN05.zip; accessed: 5 January 2011].

Erlanger TE, Krieger GR, Singer BH, Utzinger J (2008a). *The 6/94 gap in health impact assessment*. Environmental Impact Assessment Review 28: 349-358.

Erlanger TE, Sayasone S, Krieger GR, Kaul S, Sananikhom P, Tanner M, Odermatt P, Utzinger J (2008b). *Baseline health situation of communities affected by the Nam Theun 2 hydroelectric project in central Lao PDR and indicators for monitoring*. International Journal of Environmental Health Research 18: 223-42.

Filmer D, Pritchett LH (2001). *Estimating wealth effects without expenditure data or tears: an application to educational enrollments in states of India*. Demography 38: 115-132.

Finn T (2007). *A guide for monitoring and evaluating population-health-environment programs*. Washington, D.C., U.S.: MEASURE Evaluation, USAID [http://www.cpc.unc.edu/measure/publications/pdf/ms-07-25.pdf; accessed: 5 January 2011].

GAELF (2008). *Map of lymphatic filariasis endemic countries*. Liverpool, U.K.: The Global Alliance to Eliminate Lymphatic Filariasis [http://www.filariasis.org; accessed: 5 January 2011].

Gwatkin DR, Rustein S, Johnson K, Pande R, Wagstaff A (2000). *Socio-economic differences in health, nutrition, and population in the Côte d'Ivoire*. Washington, D.C, U.S.: The World Bank.

Hall A, Horton S (2008). *Best practices paper: deworming. Copenhagen Consensus 2008*. Westminster, U.K.: University of Westminster.

Harris P, Harris-Roxas B, Harris E, Kemp L (2007). *Health impact assessment: a practical guide.* Sydney, Australia: University of New South Wales Reasearch Centre for Primary Health Care and Equity and New South Wales Health.

IAIA (2010). *Official website of the International Association for Impact Assessment*. Fargo, North Dakota, U.S.: International Association for Impact Assessment [http://www.iaia.org/; accessed: 5 January 2011].

ICMM (2010). *Good practice guidance on health impact assessment*. London, U.K.: International Council on Minerals and Metals [http://www.icmm.com/page/35457/good-practice-guidance-on-health-impact-assessment; accessed: 5 January 2011].

IFC (2006a). *Performance standards*. Washington, D.C., U.S.: International Finance Corporation USA [http://www.ifc.org/ifcext/sustainability.nsf/Content/PerformanceStandards; accessed: 5 January 2011].

IFC (2006b). *Summary of project information: Simandou Iron Ore*. Washington, D.C., U.S.: International Finance Corporation [http://www.ifc.org/projects; accessed: 5 January 2011].

IFC (2007). *Guidance note 4: community health, safety and security*. Washington, D.C., U.S.: International Finance Corporation [http://www.ifc.org/ifcext/sustainability.nsf/Content/GuidanceNotes; accessed: 5 January 2011].

IFC (2009a). *Introduction to health impact assessment*. Washington, D.C., U.S.: International Finance Corporation [http://www.ifc.org/ifcext/sustainability.nsf/Content/Publications_Handbook_HealthImpactAssessment; accessed: 5 January 2011].

IFC (2009b). *Projects and people: a handbook for addressing project-induced in-migration*. Washington, D.C., U.S.: International Finance Corporation [http://www.ifc.org/ifcext/sustainability.nsf/Content/Publications_Handbook_Inmigration; accessed: 5 January 2011].

IFC (2010). *Strategic community investment: a good practice handbook for companies doing business in emerging markets*. Washington, D.C., U.S.: International Finance Corporation [http://www.ifc.org/ifcext/sustainability.nsf/Content/Publications_Handbook_CommunityInvestment; accessed: 5 January 2011].

IPIECA (2005). *A guide to health impact assessment in the oil and gas industry*. London, U.K.: International Petroleum Industry Environmental Conservation Association [http://www.ipieca.org/system/files/publications/HPI.pdf; accessed: 5 January 2011].

Joffe M, Mindell J (2005). *Health impact assessment*. Occupational and Environmental Medicine 62: 907-912.

Kemm JR (2000). *Can health impact assessment fulfil the expectations it raises?* Public Health 114: 431-433.

Krieger GR, Balge MZ, Chanthaphone S, Tanner M, Singer BH, Fewtrell L, Kaul S, Sananikhom P, Odermatt P, Utzinger J (2008). *Nam Theum 2 hydroelectric project,* *Lao PDR*. In: Fewtrell L, Kay D, editors. Health impact assessment for sustainable water management. London, U.K.: IWA Publishing.

Krieger GR, Utzinger J, Winkler MS, Divall MJ, Phillips SD, Balge MZ, Singer BH (2010). *Barbarians at the gate: storming the Gothenburg consensus*. Lancet 375: 2129-2131.

La Granada Enterprise (2008). *Etude de base socio-économique: état de référence*. Montreal, Canada: La Granada Enterprises Ltd.

Laite JA (2009). *Historical perspectives on industrial development, mining, and prostitution*. Historical Journal 52: 739-761.

Lerer LB, Scudder T (1999). *Health impacts of large dams*. Environmental Impact Assessment Review 19: 113-123.

Manderson L (1996). *Sickness and the state: health and Illness in Colonial Malaya, 1870 - 1940*. Cambridge, U.K.: Cambridge University Press.

MEASURE DHS (2010). *Malaria indicator survey*. Calverton, Maryland, U.S.: MEASURE DHS, ICF Macro. [http://www.measuredhs.com/aboutsurveys/mis/; accessed: 5 January 2011].

Mercier JR (2003). *Health impact assessment in international development assistance: the World Bank experience*. Bulletin of the World Health Organization 81: 461-462.

Mindell J, Hansell A, Morrison D, Douglas M, Joffe M (2001). *What do we need for robust, quantitative health impact assessment?* Journal of Public Health Medicine 23: 173-178.

Mindell J, Joffe M (2003). *Health impact assessment in relation to other forms of impact assessment*. Journal of Public Health Medicine 25: 107-112.

Moser CON (1998). *The asset vulnerability framework: reassessing urban poverty reduction strategies*. World Devevlopment 26: 1-19.

O'Donnell O, Van Doorsalaer E, Wagstaff A, Lindelow M (2008). *Analyzing health equity using household survey data. a guide to techniques and their implementation*. The World Bank. Washington, D.C., U.S.

Ogola JS, Mitullah WV, Omulo MA (2002). *Impact of gold mining on the environment and human health: a case study in the Migori Gold Belt, Kenya*. Environmental Geochemistry and Health 24: 141-158.

Razum O, Gerhardus A (1999). *Methodological triangulation in public health research: advancement or mirage?* Tropical Medicine and International Health 4: 243-244.

RBM (2010). *Official website of the Roll Back Malaria Partnership*. Geneva, Switzerland: Roll Back Malaria Partnership [www.rollbackmalaria.org; accessed: 5 January 2011].

Rio Tinto (2010). *Official website of the Rio Tinto Simandou project*. Conakry, Republic of Guinea: Rio Tinto Simfer SA. [http://www.riotintosimandou.com/; accessed: 5 January 2011].

Rowe AK, Kachur SP, Yoon SS, Lynch M, Slutsker L, Steketee RW (2009). *Caution is required when using health facility-based data to evaluate the health impact of malaria control efforts in Africa*. Malaria Journal 8: 3.

Rowe G, Wright G (1999). *The Delphi technique as a forecasting tool: issues and analysis*. International Journal of Forecasting 15: 353-375.

Sayasone S, Erlanger TE, Kaul S, Sananikhom P, Tanner M, Utzinger J, Odermatt P (2009). *Perceived ill-health and health seeking behaviour in two communities in the Nam Theun 2 hydroelectric project area in Lao People's Democratic Republic*. Asian Pacific Journal of Tropical Medicine 2: 63-70.

Simarro PP, Jannin J, Cattand P (2008). *Eliminating human African trypanosomiasis: Where do we stand and what comes next?* PLoS Medicine 5: 174-180.

Singer BH, Castro MC (2007). *Bridges to sustainable tropical health*. Proceedings of the National Academy of Sciences of the United States of America 104: 16038-16043.

SNC-Lavalin (2009). *Social and environmental baseline study Simandou mining area*. Montreal, Canada: SNC-Lavalin.

SNIS (2007). *Cumul des maladies traitées dans les structures sanitaires: Beyla*. Conakry, Republic of Guinea: Service National d'Information Sanitaire.

SNIS (2008). *Cumul des maladies traitées dans les structures sanitaires: Beyla.* Conakry, Republic of Guinea: Service National d'Information Sanitaire.

The Global Fund (2008). *The role of the private sector in the Global Fund to fight AIDS, Malaria andTtuberculosis: opportunities, achievements and challenges in West and Central Africa.* Geneva, Switzerland: The Global Fund to fight AIDS, Malaria and Tuberculosis.

The Global Fund (2009). *Monitoring and evaluation toolkit: HIV, tuberculosis and malaria and health system strengthening*. Geneva, Switzerland: The Global Fund to fight AIDS, Malaria and Tuberculosis. [http://www.theglobalfund.org/en/me/guidelines_tools/; accessed: 5 January 2011].

Utzinger J, Wyss K, Moto DD, Tanner M, Singer BH (2004). *Community health outreach program of the Chad-Cameroon petroleum development and pipeline project*. Clinics in Occupational and Environmental Medicine 4: 9-26.

Utzinger J, Wyss K, Moto DD, Yemadji N, Tanner M, Singer BH (2005). *Assessing health impacts of the Chad-Cameroon petroleum development and pipeline project: challenges and a way forward*. Environmental Impact Assessment Review 25: 63-93.

Wagstaff A, Paci P, Vandoorslaer E (1991). *On the measurement of inequalities in health*. Social Science and Medicine 33: 545-557.

Wang Y (2004). *Environmental degradation and environmental threats in China*. Environmental Monitoring and Assessment 90: 161-169.

Watson M (1921). *The prevention of malaria in the federated Malay States: a record of 20 years progress*. London, U.K.: John Murray.

Watson M (1953). *African highway: The battle for health in Central Africa*. London, U.K.: John Murray.

WHO (1999). *Human health and dams: the World Health Organization's submission to the World Commission on Dams*. Geneva, Switzerland: World Health Organization [http://www.hiaconnect.edu.au/files/WHO_Submission_on_Dams.pdf; accessed: 5 January 2011].

WHO (2005). *The Bangkok Charter for health promotion in a globalized world*. Geneva, Switzerland: World Health Organization [http://www.who.int/healthpromotion/conferences/6gchp/bangkok_charter/en/; accessed: 5 January 2011].

WHO (2009). *Global alert and response (GAR): Guinea*. Geneva, Switzerland: World Health Organization [http://www.who.int/csr/don/archive/country/gin/en/; accessed: 5 January 2011].

WHO/UNICEF (2008). *A snapshot of drinking water and sanitation in Africa*. Geneva, Switzerland: WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation [http://www.who.int/water_sanitation_health/monitoring/africasan.pdf; accessed: 5 January 2011].

Winkler MS, Divall MJ, Krieger GR, Balge MZ, Singer BH, Utzinger J (2010). *Assessing health impacts in complex eco-epidemiological settings in the humid tropics: advancing tools and methods*. Environmental Impact Assessment Review 30: 52-61.

4. Assessing health impacts in complex eco-epidemiological settings in the humid tropics: modular baseline health surveys

Mirko S. Winkler[a,b], Mark J. Divall[c], Gary R. Krieger[d], Sandro Schmidlin[a,b], Mohamed L. Magassouba[e], Astrid M. Knoblauch[c], Burton H. Singer[f], Jürg Utzinger[a,b,*]

[a] *Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, P.O. Box, CH-4002 Basel, Switzerland*

[b] *University of Basel, P.O. Box, CH-4003 Basel, Switzerland*

[c] *NewFields, LLC, Pretoria 0062, South Africa*

[d] *SHAPE Consulting Ltd., Denver, CO 80202, USA*

[e] *Clinique Ambroise Paré, P.O. Box, 1042 Conakry, Republic of Guinea*

[f] *Emerging Pathogens Institute, University of Florida, Gainesville, FL 32610, USA*

* Corresponding author. Jürg Utzinger, Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, P.O. Box, CH-4002 Basel, Switzerland. Tel.: +41 61 284-8129; fax: +41 61 284-8105. *E-mail address:* juerg.utzinger@unibas.ch (J. Utzinger).

This article has been published in

Environmental Impact Assessment Review 2012, 33: 15-22

4.1. Abstract

The quantitative assessment of health impacts has been identified as a crucial feature for realising the full potential of health impact assessment (HIA). In settings where demographic and health data are notoriously scarce, but there is a broad range of ascertainable ecological, environmental, epidemiological and socio-economic information, a diverse toolkit of data collection strategies becomes relevant for the mainly small-area impacts of interest. We present a modular, cross-sectional baseline health survey study design, which has been developed for HIA of industrial development projects in the humid tropics. The modular nature of our toolkit allows our methodology to be readily adapted to the prevailing eco-epidemiological characteristics of a given project setting. Central to our design is a broad set of key performance indicators, covering a multiplicity of health outcomes and determinants at different levels and scales. We present experience and key findings from our modular baseline health survey methodology employed in 14 selected sentinel sites within an iron ore mining project in the Republic of Guinea. We argue that our methodology is a generic example of rapid evidence assembly in difficult-to-reach localities, where improvement of the predictive validity of the assessment and establishment of a benchmark for longitudinal monitoring of project impacts and mitigation efforts is needed.

Keywords: Health impact assessment; Baseline health survey; Key performance indicators; Developing country; Industrial development project; Republic of Guinea.

4.2. Introduction

Health impact assessment (HIA) entails the systematic analysis of potential impacts on public health due to policies, programmes and projects, and aims to optimise the health interests in the decision-making process (Kemm et al., 2004). HIA usually embraces an interdisciplinary approach, combining quantitative and qualitative methods, to guide evidence-based mitigation measures (Scott-Samuel, 1998; Lock, 2000; Krieger et al., 2003). HIA has progressively developed over the past 20 years with continued diversification in approaches, methods, tools and guiding frameworks (Krieger et al., 2010; Harris-Roxas and Harris, 2011). The salient issues in natural resources and industry development projects in the developing world are quite different from those associated with an advanced economy policy or programme. Given the enormous, resource-driven (i.e. biofuels, mining, oil/gas, water and timber) development that is occurring in low-income, but resource-rich countries (Erlanger et al., 2008a), there is a need to identify the most useful approaches and techniques for characterising the baseline situation. Defining the baseline is a crucial exercise, as subsequent monitoring and evaluation (M&E) activities and documentation of positive and negative effects will be dependent on the accuracy of the baseline determination. In a developing country setting, obtaining relevant baseline data in an efficient and cost-effective manner is a complex, yet important undertaking.

In general, HIA practitioners draw on epidemiological evidence that is readily available, and critically assess its relevance for particular circumstances of a specific proposal (Mindell et al., 2004). In a developing country context, population-based surveys such as demographic health surveys (DHS), multiple indicator cluster surveys (MICS) and health statistics reported by the World Health Organization (WHO) and other organisations typically provide epidemiological data on a national or regional level. While such data are relevant for impact assessment of national policies and programmes, they are often inapplicable for M&E of a specific project at a community level. Settings that are characterised by profound micro-environmental differences (e.g., altitude, humidity, land-use patterns, rainfall and temperature), and large disparities of access to health care, have important ramifications on local burdens of disease (Listorti and Doumani, 2001; Schellenberg et al., 2003; Utzinger and Keiser, 2006; Eisenberg et al., 2007; Prüss-Üstün et al., 2008). Regional or national data typically obscure or overtly miss critical small area morbidity/mortality differences. Hence, for robust risk appraisal and documenting changing patterns of health, wellbeing and equity following project implementation, adequate tools for quantification at a local level are required (Utzinger et al., 2005; Winkler et al., 2010; Bhatia and Seto, 2011).

The baseline analysis is tied to, and sequentially follows, the initial scoping analysis. Scoping identifies the range of potential health impacts and determines, by means of a gap analysis, whether sufficient data are available in order to proceed directly with the risk/impact analysis and mitigation phase (Winkler et al., 2011). In case of inadequate or insufficient data, there is a need to collect additional baseline health data. In low-income countries, critical data gaps are the norm rather than the exception (Thamlikitkul, 2006; Adrien et al., 2008). Hence, it is essential to develop a standardised, rapid and inexpensive baseline health survey methodology that incorporates a broad set of practical and readily reproducible key performance indicators (KPIs) that can be adapted to the magnitude and complexity of myriad project settings. In this context, we have developed a modular, cross-sectional baseline health survey methodology that has been successfully applied in a number of projects, countries and environmental settings across sub-Saharan Africa and elsewhere. In the present paper, our methodology is illustrated by a baseline health survey carried out in 14 sentinel sites located within the concession area of a mining project in West Africa.

4.3. Methods

4.3.1. Key performance indicators (KPIs)

KPIs are measures of project inputs, outputs, outcomes and impacts that are monitored during project implementation (Mosse and Sontheimer, 1996). From a practical point of view, three data collection levels exist, each of which offers a set of specific indicator groups: (i) individual level (e.g., age and sex, indicators of knowledge, attitude and practice (KAP) and biomedical indicators); (ii) household level (e.g., structural indicators, such as durable housing characteristics, asset indicators (e.g., possession of a radio or bicycle) and environmental indicators); and (iii) community level (e.g., health systems, infrastructure indicators and environmental indicators).

For the data collection *per se*, different data collection tools and methods (referred to as ‘modules’) are at our disposal. Figure 4.1 shows the interlinkages between the different data collection levels, the indicator groups and the data collection modules, including a broad, but focused set of potential KPIs. Importantly, the aforementioned indicators need specificity in terms of the final dimension unit and the precise manner of assessment.

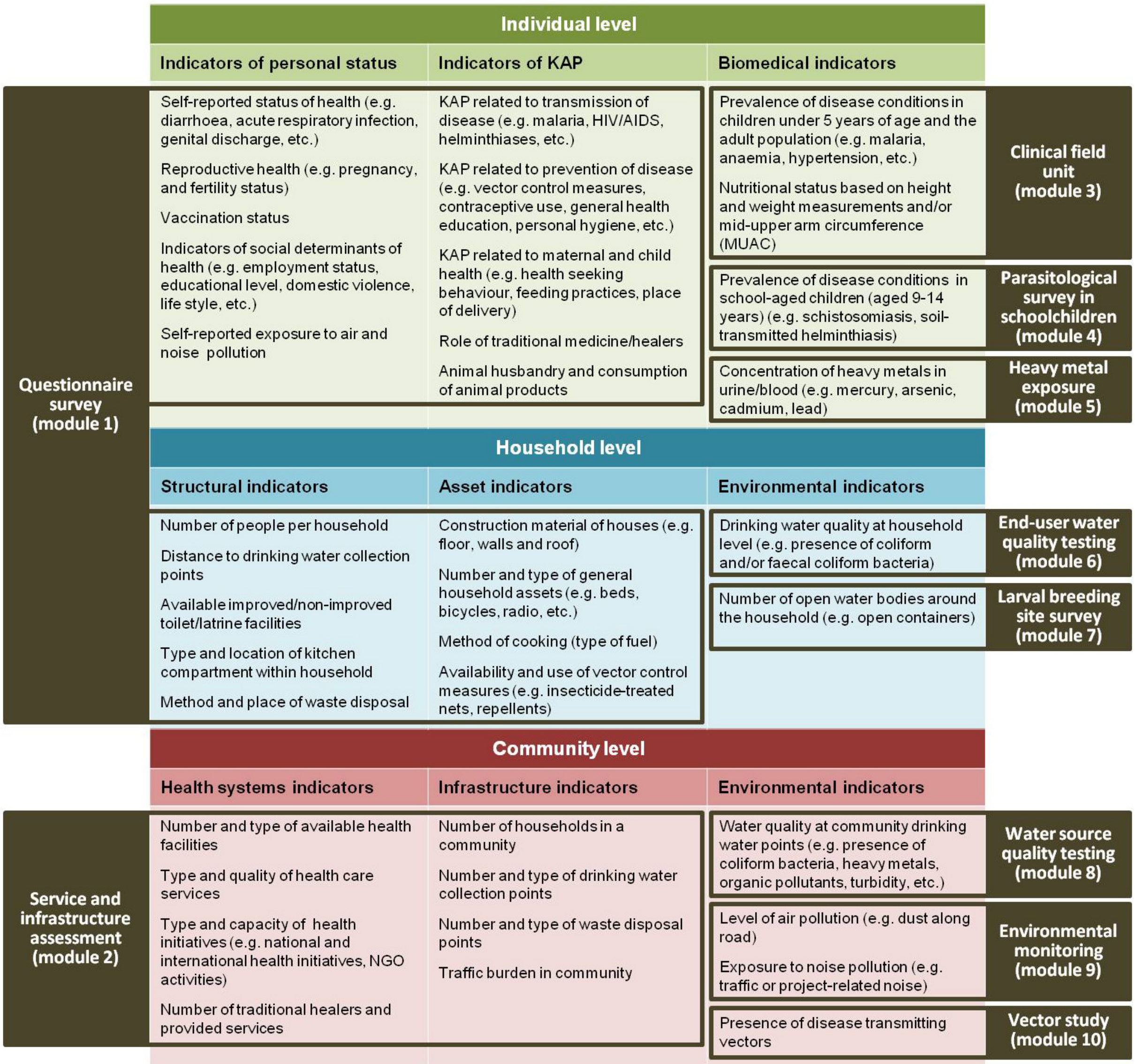


Figure 4.1: Key performance indicators (KPIs) that can be readily obtained in a modular approach as part of a cross-sectional baseline health survey in the frame of HIA of projects in the developing world.

4.3.2. Study design

The design of a HIA baseline health survey is governed by the fact that it should reflect the heterogeneity of health characteristics and potential project-related impacts (beneficial or detrimental) among different communities and/or population groups. Hence, a central feature of baseline health surveys for industrial projects is that data collection methods need to be fine-tuned to local small-area conditions. A broad-based tool kit is essential. In our view, the standardised sampling methodologies advertised for large-scale national and regional surveys are, for the most part, inapplicable to typical industrial project settings (United Nations, 2008). Against this background, we developed a three-stage sampling strategy, which is purposive at the first two stages and randomised at the third stage (see Figure 4.2).

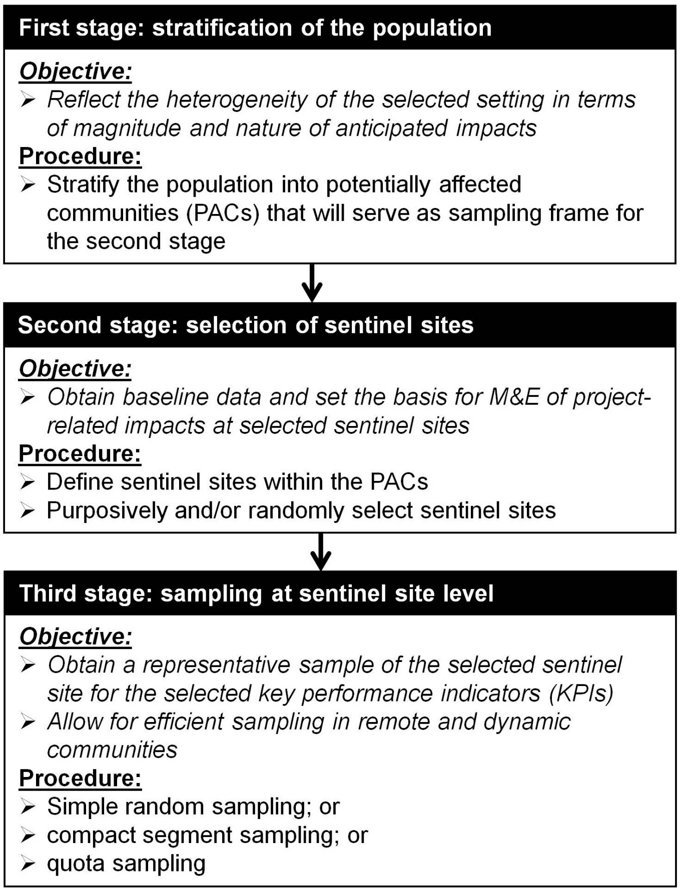


Figure 4.2: Three-stage sampling strategy with specific objectives and procedures at the different stages.

In the frame of a baseline health survey as part of a HIA of a project, stratified sampling is recommended at the first stage. The population is stratified into so-called potentially affected communities (PACs). We define PAC as a community within a well-defined geographical boundary under the assumption that it will be equally exposed to the project in terms of the magnitude and nature of the anticipated impacts (Winkler et al., 2010). Examples of PACs are communities along a major access road of a project, or communities to be resettled, or communities not directly affected by a project are examples of PACs. The definition of PACs is project specific, and thus based on available socio-economic and environmental baseline data, supplemented with findings from the scoping study.

At the second stage, primary sampling units are defined and selected within a PAC and referred to as sentinel sites. A sentinel site is defined as a geographically constructed area (e.g., sentinel village), or a part of an area (e.g., neighbourhood in a town), with up to 300 households. The number and selection procedure (i.e., purposive or random) of sentinel sites is governed by the magnitude and heterogeneity of the project area, financial and human resources, operational issues and technical considerations.

At the third stage, when data collection occurs at sentinel site level, a diverse array of options must be considered on a site-specific basis. Ideally, a complete list of households or residential dwellings serves as sampling frame for simple random sampling (Aliaga and Ren, 2006). In rural areas of the developing world, where household lists may not be readily available, the following alternatives exist. First, compact segment sampling is a useful technique (Turner et al., 1996). Here, a sketch map is drawn of the sentinel site, showing dwellings, which is then split into a small number of segments, such that the number of dwellings per segment is roughly the same (e.g., 30 households). One segment is then chosen at random from each sentinel site and all households in the segment are included in the sample. Further, a quota sample method lends itself when no mapping material is at hand. For this, a top with a marked cross on it is spun at a central point within a sentinel site to determine four perpendicular directions. Subsequently, the households along these directional lines to the edge of the cluster area are counted, and one in each direction selected at random. Proximity sampling is then pursued with interviewers moving from one household to the next nearest household until the pre-determined number of households is reached. These sampling methods may be augmented by purposive selection of key sites not located on transects, but which have the potential for high impacts.

The optimal sample size at sentinel site level is usually a trade-off between the available budget and the desired survey precision. DHS experience suggests that, for an average cluster size of 100-300 households, to achieve moderate intra-cluster correlation and an acceptable cost ratio, the optimal second-stage sample size is about 20-30 women per cluster for gathering data on most of the survey indicators (Aliaga and Ren, 2006). DHS are similar in terms of field procedures and measured indicators, and thus this range is utilised as reference for the number of individuals and households selected per sentinel site.

4.3.3. Data collection modules

The final setup of a baseline health survey is determined by the selected KPIs of interest, as they indicate which of the 10 data collection modules presented in Figure 4.1 should be used. The selection of the modules to be employed is governed by the data needs, whereas human resources and equipment required are carefully determined. The set of modules depends on the sample size, sampling strategy and available data. For example, to gather community-level information on structural and institutional indicators, module 2 is employed (service and infrastructure assessment), whereas for obtaining environmental indicators, modules 6-10 are used, which require special equipment and specific considerations regarding sampling procedures. A questionnaire survey (module 1), end-user water quality testing (module 6) and a clinical field unit (module 3) may be linked by using the household as the common unit of sampling. This means that the assessor collects a drinking water sample after conducting an interview and subsequently refers household members to a clinical field unit where they are examined by a medical team for clinical investigation. While in some cases there is an advantage to linking different modules, the opposite may apply for modules such as a parasitological survey in schoolchildren (module 4) or an entomological survey that focuses on disease vectors (module 10). These surveys are preferably led by independent and specialised teams, as they do not have a common sampling unit with other teams and also the daily schedule may differ.

4.4. Case study

4.4.1. Study area and compliance

Our case study pertains to a baseline health survey carried out for the Rio Tinto Simandou project in May 2010. This project is a large iron ore mining exploration currently at feasibility stage, located in the south-eastern part of the Republic of Guinea (Rio Tinto, 2010). An estimated 60,000 people reside in the administrative area around the mine concession, affecting four sub-districts with 31 settlements (ranging from small hamlets with less than 40 individuals to a town with 22,000 inhabitants) (Rey, 2008; SNC-Lavalin, 2009). Details of this project, together with our approach for, and key findings from, the HIA scoping have been presented elsewhere (Divall and Winkler, 2009; Winkler et al., 2011).

In collaboration with the socio-economic baseline study team and the community relations team, the project area was stratified into eight PACs, within which 14 sentinel sites were selected (Figure 4.3). In the absence of household lists and mapping material for the remote communities, households were selected using the quota sample method described in section 2.2. An estimated 26,000 people live in the 14 sentinel sites, in approximately 3,500 households (Rey, 2008; SNC-Lavalin, 2009). Overall, 451 households (13.3% of the total estimated households) participated in the questionnaire survey. Clinical field unit investigation focussed on 1,511 individuals (813 children aged 6-59 months and 698 adolescents and adults aged ≥15 years), which represents 7.7% of the estimated population in these age groups. Table 4.1 provides further details on sampling, stratified by sentinel site and module.

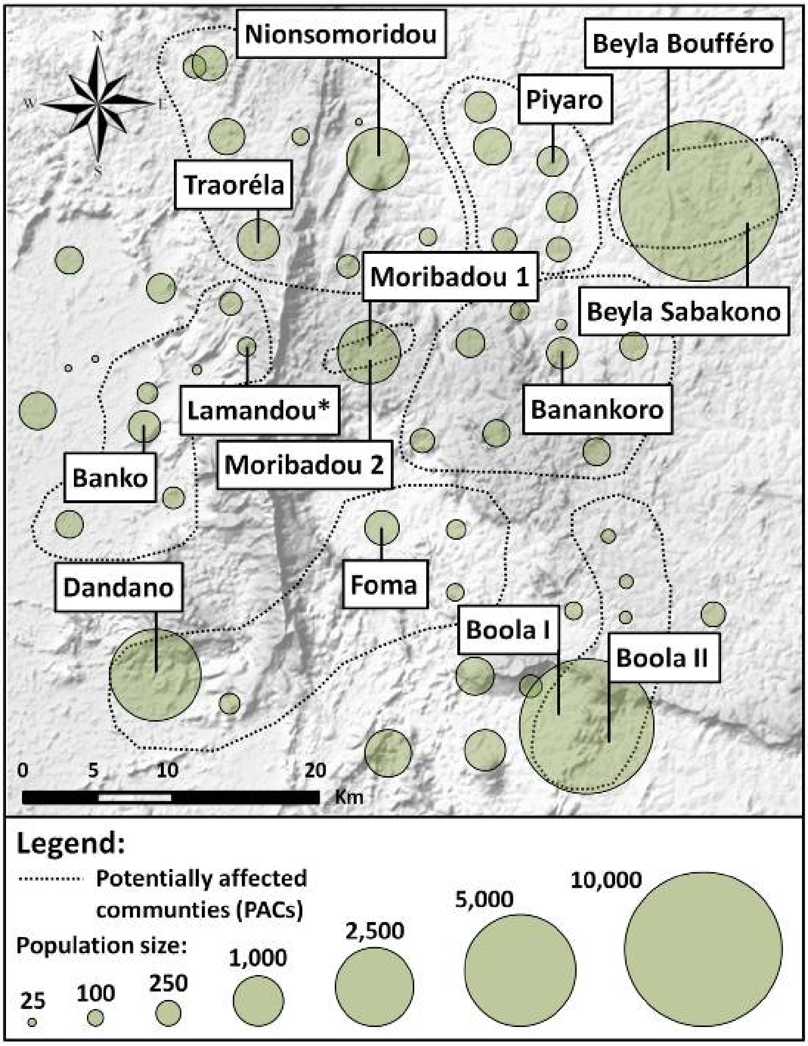


Figure 4.3: Map showing communities and selected sentinel sites in the Simandou mining project region in the Republic of Guinea, including the estimated population size.
(* Could only be surveyed by the parasitological survey team.)

Table 4.1: Population estimates and study compliance of questionnaire survey (module 1), field laboratory (module 3) and parasitological survey in schoolchildren (module 4) during a baseline health survey conducted in 14 sentinel sites of a mining project in the Republic of Guinea in mid-2010.

	Population estimates per sentinel site		**Questionnaire survey (module 1)**		**Clinical field unit (module 3)**			**Parasitological survey (module 4)**
Sentinel sites	Estimated population numbers	Estimated number of households	Number of households sampled (% of total households)	Number of individuals aged ≥15 years (male:female)	Children aged 6-59 months (male:female)	Adults aged ≥15 years (male:female)	Total (% of represented population[a])	Total children aged 9-14 years (male:female)
Nionsomoridou	2,132	237[b]	24 (10.1)	24 (11:13)	55 (26:29)	63 (17:46)	118 (7.4)	30 (21:9)
Piyaro	508	56b[b]	30 (53.6)	30 (15:15)	64 (27:37)	54 (16:38)	118 (31.0)	30 (16:4)
Traoréla	952	106[b]	30 (28.3)	30 (15:15)	54 (28:26)	53 (20:33)	107 (15.0)	30 (24:6)
Beyla Sabakono	4,921	875	40 (4.6)	40 (20:20)	67 (39:28)	71 (14:57)	138 (3.7)	30 (20:10)
Beyla Bouffèro	2,712	384	39 (10.1)	39 (19:20)	114 (57:57)	56 (8:48)	170 (8.4)	30 (20:10)
Moribadou 1	} 3,806	422[b]	80 (19.0)	40 (20:20)	51 (25:26)	47 (14:33)	187 (6.6)	30 (13:7)
Moribadou 2				40 (20:20)	51 (28:23)	38 (8:30)		30 (18:2)
Foma	636	60	28 (46.7)	28 (15:13)	40 (24:16)	50 (19:31)	90 (18.9)	30 (27:3)
Boola I	} 4,713	524[b]	80 (15.3)	40 (20:20)	51 (21:30)	53 (13:40)	212 (6.0)	30 (14:16)
Boola II				40 (20:20)	62 (32:30)	46 (10:36)		30 (30:0)
Lamandou	195	30	n.a.[c]	n.a.[c]	n.a.[c]	n.a.[c]	n.a.[c]	30 (12:18)
Banko	558	62[b]	30 (48.4)	30 (16:14)	58 (25:33)	56 (17:39)	114 (27.2)	30 (16:14)
Dandano	4,536	612	40 (6.5)	40 (20:20)	76 (34:42)	54 (10:44)	130 (3.8)	30 (15:15)
Banankoro	536	60[b]	30 (50.0)	30 (15:15)	70 (40:30)	57 (20:37)	127 (31.6)	30 (16:14)
Total	**26,205**	**3,428**	**451 (13.3)**	**451 (226:225)**	**813 (406:407)**	**698 (186:512)**	**1,511 (7.7)**	**420 (262:158)**

[a] Based on the assumptions that 20% of the population is aged 5-59 months and 55% of the population is aged ≥15 years

[b] Based on an average number of 9 people per household

[c] Due to a very unfortunate incident, Lamandou could only be sampled by the parasitological survey team

4.4.2. Study setup and equipment

Use of module 1 (questionnaire survey), module 2 (service and infrastructure assessment), module 3 (clinical field unit), module 4 (parasitological survey in schoolchildren), module 6 (end-user water quality testing) and module 8 (water source quality testing) covered approximately 60 specific KPIs. The surveys were conducted by three teams: (i) six interviewers administering a questionnaire survey at household level (module 1), (ii) three medical doctors accompanied by two nurses performing clinical investigations at the clinical field unit (module 3), and (iii) two epidemiologists together with five laboratory technicians conducting parasitological surveys in schoolchildren (module 4). As preparatory steps for the surveys, the locally recruited staff were trained in interview techniques, laboratory procedures and quality control. Questionnaires were pre-tested in a village that was not selected for the survey. Prior to the surveys, the 14 sentinel sites were visited by a community consultation team to inform community leaders, traditional village chiefs and community members about the purpose and procedures of the study.

For this paper, a selection of results will be presented, following standard protocols. First, the extent of malaria was assessed from a finger prick blood sample using a rapid diagnostic test (RDT) for appraisal of *Plasmodium* infection (ICT malaria combo cassette test; ICT Diagnostics, Cape Town, South Africa). Second, a stool sample was collected and subjected to the Kato-Katz thick smear technique for diagnosis of *Schistosoma mansoni* and common soil-transmitted helminths (*Ascaris lumbricoides*, hookworm and *Trichuris trichiura*) (Katz et al., 1972). Third, urine samples were examined for *Schistosoma haematobium*, using the centrifugation method (Hodges et al., 2011). Finally, the presence/absence of coliform bacteria and *Escherichia coli* were determined, using a Colitag^{TM} water test (CPI International; Santa Rosa, CA, USA).

4.4.3. Ethical considerations and treatment

The study was approved by the ethics committee of the Ministry of Health and Public Hygiene (MHPH) of the Republic of Guinea (Ref. no. 07/CNERS/10). The study is registered at Current Controlled Trials (identifier: ISRCTN88762301). Written informed consent was obtained from all the study participants, and the parents/legal guardians of children below the age of 16 years. Individuals who were found positive for *Plasmodium* infection by a RDT, were infected with soil-transmitted helminths or *S. mansoni*, as determined by parasite eggs in a Kato-Katz thick smear, showed *S. haematobium* eggs in their urine, had severe anaemia or other aliments were treated according to national policies, free of charge.

4.5. Results

To illustrate the methodology, selected KPIs pertaining to malaria, helminth infections, sanitation and drinking water, and access to health care are presented (Divall et al., 2010). Of note, due to unforeseen circumstances, one of the sentinel sites (i.e. Lamandou), could only be sampled by the parasitological school survey team. Hence, complete data sets are available for 13 of the 14 selected sentinel sites.

4.5.1. Malaria

Overall, 813 children aged 6-59 months were examined for *Plasmodium* infection at 13 sentinel sites by means of a RDT. A total of 536 children tested positive, owing to an overall prevalence of 65.9%. Stratified by sentinel site, the prevalence ranged from 53.6% (Traoréla, 54 children tested) to 92.6% (Piyaro, 64 children tested) (Figure 4.4). For comparison, according to data presented by the much more coarse-grained malaria atlas project (MAP) (Hay and Snow, 2006), the prevalence of malaria is 50-60% for the current study area. At the sentinel sites, boys were significantly more often infected with *Plasmodium* than girls (70.4% *vs.* 61.4%, $p = 0.007$). Those children who slept under an insecticide-treated net (ITN) the night before the survey took place were selected as a KPI for malaria prevention. The lowest rate was observed in Banankoro (22.0%) and the highest in Traoréla (86.0%), indicating considerable inter-site variability. Of note, some communities benefitted from a recent ITN distribution campaign. This might explain that the ITN coverage was considerably higher (average: 50.3%) than the regional average (8.6-11.0%) according to the 2005 Guinean DHS (GDHS) (Direction Nationale de la Statistique (DNS) and ORC Macro, 2006) and the national survey on the nutritional status and key indicators of child survival 2008 (NSCS) (DNS, 2008). Also KAPs related to malaria transmission and prevention showed considerable variations from one sentinel site to another. For example, the portion of the adolescent/adult population (aged ≥15 years) that reported 'being bitten by mosquitoes' as mode of malaria transmission ranged from 61.5% to 87.5%.

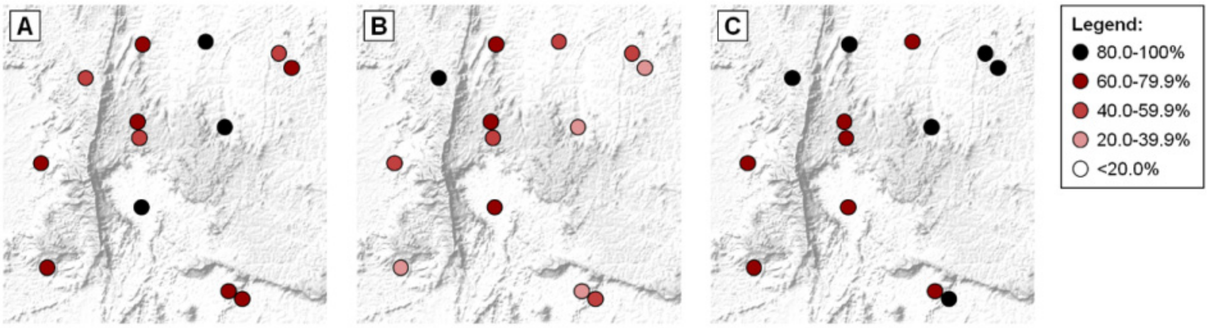


Figure 4.4: Selected findings related to malaria; (A) children aged 6-59 months (%) tested positive for *Plasmodium* infection; (B) children under the age of 5 years (%) who slept under an insecticide-treated net; and (C) adolescents/adults (aged ≥15 years) (%) who reported mosquito bites as malaria transmission mode.

4.5.2. Helminth infections, sanitation and drinking water

The survey on helminth infections in schoolchildren (aged 9-14 years) revealed that *S. mansoni* is the predominant species (overall prevalence 66.2%, range: 13.3-90.0%). *S. haematobium* was found in 21.0% of the children surveyed (range: 0-76.7%). The prevalence of hookworm, *A. lumbricoides* and *T. trichiura* was 51.2% (range: 6.7-93.3%), 8.1% (range: 0-33.3%) and 2.4% (range 0-6.7%), respectively (Hodges et al., 2011).

Compared to the regional average of 21.1% (DNS, 2008), 78.5% of the investigated households ($n = 441$) had open pit latrines, ranging from 41.7% (Nionsomoridou) to 100% (Foma and Banko) (Figure 4.5). Approximately half of the interviewed adolescents/adults reported regularly washing their hands with soap; the lowest percentage was found in Banko (29.6%) and the highest in Nionsomoridou (78.9%).

Tube wells are the preferred source of drinking water in the project region. At eight of the 13 sentinel sites, over 80% of the households use well water for drinking purpose. From the 206 drinking water samples that were collected at every second surveyed household, 157 (76.2%) were found positive for *E. coli*. This high level of contamination can partially be explained by poor well water quality (six of 37 wells (16.2%) showed contamination with *E. coli*) (Figure 4.5).

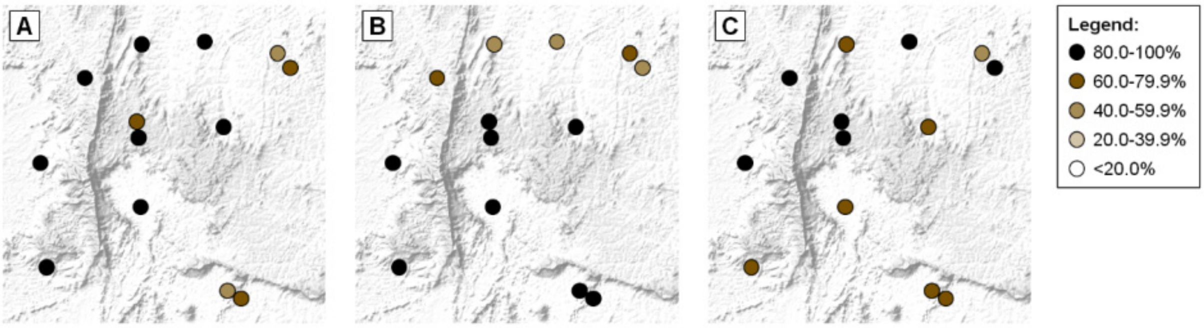


Figure 4.5: Selected findings related to sanitation and drinking water quality; (A) households (%) having an open pit latrine; (B) households (%) using a tube well as main drinking water source; and (C) households (%) that had *E. coli* contaminated drinking water.

4.5.3. Access to health care

On average, 68.1% of the parents ($n = 745$) sought care at a health facility the last time their youngest child was sick. In those communities without a health centre, the utilisation rate was, as expected, poorer. As seen in Figure 4.6, this was particularly evident in Foma (28.8%). Among parents who did not take their children to a health facility, non-affordability was the primary reason (40.3%).

Of the 180 interviewed mothers, 64.1% reported that their last child was delivered in a health facility, which is similar to the regional average of 68.7% (DNS and ORC Macro, 2006). Of note, for Traoréla and Foma, the two most remote sentinel sites, none or only 11.1% of the mothers interviewed reported that they had delivered their last child in a health facility, respectively. In contrast, at the sentinel sites where a health post or a health centre is available, generally more than 80% of the women delivered at these facilities.

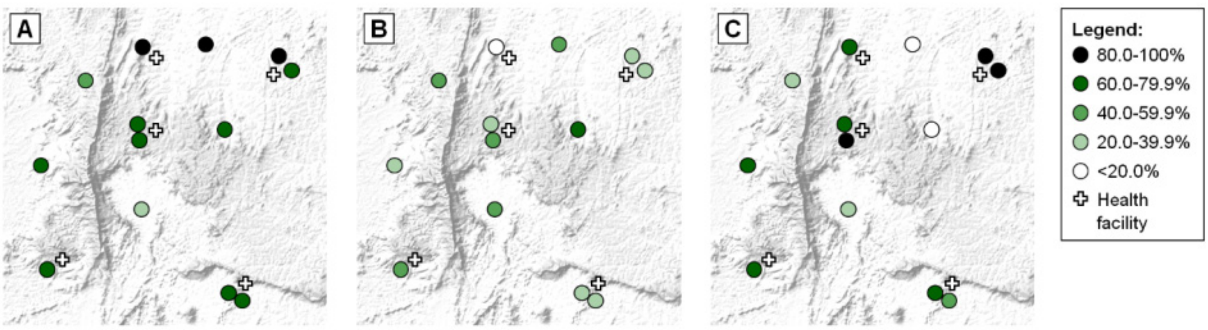


Figure 4.6: Selected findings related to health care; (A) mothers (%) who went to a health facility when their child was sick (cross: health facility available); (B) mothers (%) who reported affordability as primary reason for not going to the health facility; and (C) mothers (%) who had their last delivery at a health facility.

4.6. Discussion

Quantitative assessments of health impacts and the need for adequate tools and methods have been identified as important features for realising the full potential of a HIA (Mindell et al., 2001; Veerman et al., 2005; Bhatia and Seto, 2011). In areas where demographic, ecological, environmental, epidemiological, health and socio-economic data are sparse, these are anticipated to be highly heterogeneous. This quantitative documentation gap hampers long-term M&E activities (Eisenberg et al., 2007). Although, the most relevant international guidelines on HIA consider baseline data collection as integral part of a comprehensive assessment, it is interesting to note that none provides clear guidance on how to perform a representative baseline health survey (IPIECA, 2005; IFC, 2009; WHO, 2009; ICMM, 2010). With the modular baseline health survey methodology presented here, we have addressed this shortcoming by providing a 'hands-on' tool that is designed for the context of complex industrial development projects implemented in remote rural areas of a developing country. The modular framework does not only provide the flexibility to exclude or incorporate further modules according to identified data gaps, but also provides overall guidance for the planning of a baseline health survey, including required study instruments, and thus equipment, logistics and personnel. The broad set of KPIs is guiding our baseline health survey approach for obtaining quantitative and defendable baseline health data.

Our case study pertaining to the baseline health survey of the Rio Tinto Simandou project region in the Republic of Guinea primarily used quantitative methods. However, KAP surveys supplemented qualitative data, which further strengthened the local-level baseline evidence. Essential data gaps had previously been identified (e.g., extent and magnitude of malaria, schistosomiasis and soil-transmitted helminth infections), during the scoping analysis (Winkler et al., 2011). There were marked differences when comparing our findings to the available regional level data (DNS and ORC Macro, 2006; DNS, 2008). This finding illustrates the importance of developing appropriate, local level baseline data. In turn, the obtained data can serve as benchmark for subsequent M&E activities.

Against the background of considerable heterogeneity and dynamics within a small geographical area and over a small temporal scale, the data collection strategy becomes of central importance. The definition of a suitable measurement strategy is a challenging task, particularly when there is a large number of indicators of different qualities (Bennett et al., 1991; Katz, 1995; Bilukha, 2008; Deitchler et al., 2008). Sentinel surveillance, focused on PACs, is a primary basis for answering epidemiological questions and monitoring trends in selected population groups impacted by industrial projects (WHO, 1999; Bachmann et al., 2003; Randrianasolo et al., 2010). In our view, the combination of a sentinel site approach with modular surveys tied to specific KPIs is an efficient and cost-effective approach for objectively documenting the baseline health situation of affected communities. The case study presented here, and our experience and lessons learnt while conducting baseline health surveys for large industrial development projects elsewhere in the tropics (Erlanger et al., 2008b), has demonstrated the feasibility and promise of this methodology.

In conclusion, a modular cross-sectional baseline health survey methodology should be considered as a key strategic option for conducting HIA in complex settings where considerable heterogeneities are anticipated in terms of small-scale eco-epidemiological characteristics and potential health impacts. HIA can reinforce the importance of health within the overall suite of impact assessments by documenting baseline conditions in a practical manner that will allow for objective, longitudinal monitoring. The dictum “if you can’t measure it, you can’t manage it” should continue to be embraced by the HIA community as a core practice component. Our experiences made thus far are that the modular survey methodology techniques presented in this paper further facilitate this process.

4.7. Acknowledgements

This paper is dedicated to Aliou Bah, a wonderful man with an amazing disposition and dedication for community engagement and field work, who sadly passed away during the cross-sectional survey conducted in one of the sentinel sites. Thanks are addressed to the baseline health survey team for their outstanding contribution, all the study participants for their commitment, Frédéric Chenais and Catherine Garcia from Rio Tinto Simandou project for the collaboration, and the national and local health authorities for their kind support and interest. We would also like to thank Dr. Jan Hattendorf from the Swiss Tropical and Public Health Institute (Swiss TPH) for statistical advice. Mirko S. Winkler is grateful to NewFields for a PhD fellowship and Sandro Schmidlin acknowledges financial support from the Swiss Tropical and Public Health Institute (teaching and training).

4.8. References

Adrien MH, Bamberger M, Conner RF, Djokovic-Papic D, Hancioglu A, Jankovic V, Jobin D, Vestman OK, Kusek JZ, Mackay K, McWhinney D, Parker D, Petrovic O, Pron N, Segone M, Rist R, Salah MA, Vadnais D, Vasic V, et al. (2008). *Bridging the gap: the role of monitoring and evaluation in evidence-based policy making*. New York, U.S.: The United Nations Children's Fund.

Aliaga A, Ren R (2006). *The optimal sample sizes for two-stage cluster sampling in demographic and health surveys*. Calverton, Maryland, U.S.: MEASURE DHS, ORC Macro.

Bachmann LH, Macaluso M, Hook EW (2003). *Demonstration of declining community prevalence of Chlamydia trachomatis infection using sentinel surveillance*. Sexually Transmitted Diseases 30: 20-24.

Bennett S, Woods T, Liyanage WM, Smith DL (1991). *A simplified general method for cluster-sample surveys of health in developing countries*. World Health Statistics Quarterly 44: 98-106.

Bhatia R, Seto E (2011). *Quantitative estimation in health impact assessment: opportunities and challenges*. Environmental Impact Assessment Review 31: 301-309.

Bilukha OO (2008). *Old and new cluster designs in emergency field surveys: in search of a one-fits-all solution*. Emerging Themes in Epidemiology 5: 7.

Deitchler M, Deconinck H, Bergeron G (2008). *Precision, time, and cost: a comparison of three sampling designs in an emergency setting*. Emerging Themes in Epidemiology 5: 6.

Direction Nationale de la Statistique (2008). *Enquête nationale sur l'état nutritionnel et le suivi des principaux indicateurs de survie de l'enfant (rapport provisoire)*. Conakry, Republic of Guinea: Direction Nationale de la Statistique, Ministère du Plan.

Direction Nationale de la Statistique, ORC Macro (2006). *Enquête démographique et de santé, Guinée 2005*. Conakry, Republic of Guinea and Claverton, Maryland, U.S.: Direction Nationale de la Statistique, Ministère du Plan et ORC Macro.

Divall MJ, Winkler MS (2009). *Health impact assessment scoping study: Rio Tinto Simandou project mining area*. Irene, Pretoria, South Africa: NewFields LLC.

Divall MJ, Winkler MS, Knoblauch AM, Schmidlin S, Andoseh V, Hodges M (2010). *Baseline health survey: Rio Tinto Simandou project mining area*. Irene, Pretoria, South Africa: NewFields LLC.

Eisenberg JNS, Desai MA, Levy K, Bates SJ, Liang S, Naumoff K, Scott JC (2007). *Environmental determinants of infectious disease: a framework for tracking causal links and guiding public health research*. Environmental Health Perspectives 115: 1216-1223.

Erlanger TE, Krieger GR, Singer BH, Utzinger J (2008a). *The 6/94 gap in health impact assessment*. Environmental Impact Assessment Review 28: 349-358.

Erlanger TE, Sayasone S, Krieger GR, Kaul S, Sananikhom P, Tanner M, Odermatt P, Utzinger J (2008b). Baseline health situation of communities affected by the Nam Theun 2 hydroelectric project in central Lao PDR and indicators for monitoring. International Journal of Environmental Health Research 18: 223-242.

Harris-Roxas B, Harris E (2011). *Differing forms, differing purposes: a typology of health impact assessment*. Environmental Impact Assessment Review 31: 396-403.

Hay SI, Snow RW (2006). *The malaria atlas project: developing global maps of malaria risk.* PLoS Medicine 3: e473.

Hodges M, Koroma M, Baldé MS, Turay H, Fofanah I, Bah A, Divall MJ, Winkler MS, Zhang Y (2011). *Current status of schistosomiasis and soil-transmitted helminthiasis in Beyla and Macenta Prefecture, Forest Guinea*. Transactions of the Royal Society of Tropical Medicine and Hygiene 105: 672-674.

ICMM (2010). *Good practice guidance on health impact assessment*. London, U.K.: International Council on Minerals and Metals [http://www.icmm.com/page/35457/good-practice-guidance-on-health-impact-assessment; accessed: 24 September 2011].

IFC (2009). *Introduction to health impact assessment*. Washington, D.C., U.S.: International Finance Corporation [http://www.ifc.org/ifcext/sustainability.nsf/Content/Publications_Handbook_HealthImpactAssessment; accessed: 24 September 2011].

IPIECA (2005). *A guide to health impact assessment in the oil and gas industry*. London, U.K.: International Petroleum Industry Environmental Conservation Association [http://www.ipieca.org/system/files/publications/HPI.pdf; accessed: 24 September 2011].

Katz J (1995). *Sample-size implications for population-based cluster surveys of nutritional-status*. American Journal of Clinical Nutrition 61: 155-160.

Katz N, Chaves A, Pellegrino J (1972). *A simple device for quantitative stool thick-smear technique in schistosomiasis mansoni*. Revista do Instituto de Medicina Tropical de São Paulo 14: 397-400.

Kemm J, Parry J, Palmer S (2004). *Health impact assessment: concepts, theory, techniques, and applications*. Oxford, U.K.: Oxford University Press.

Krieger GR, Utzinger J, Winkler MS, Divall MJ, Phillips SD, Balge MZ, Singer BH (2010). *Barbarians at the gate: storming the Gothenburg consensus*. Lancet 375: 2129-2131.

Krieger N, Northridge M, Gruskin S, Quinn M, Kriebel D, Smith GD, Bassett M, Rehkopf DH, Miller C (2003). *Assessing health impact assessment: multidisciplinary and international perspectives*. Journal of Epidemiology and Community Health 57: 659-662.

Listorti JA, Doumani FM (2001). *Environmental health: bridging the gaps*. World Bank Discussion Paper No. 422. Washington, D.C., U.S.: The World Bank.

Lock K (2000). *Health impact assessment*. BMJ 320: 1395-1398.

Mindell J, Boaz A, Joffe M, Curtis S, Birley M (2004). *Enhancing the evidence base for health impact assessment*. Journal of Epidemiology and Community Health 58: 546-551.

Mindell J, Hansell A, Morrison D, Douglas M, Joffe M (2001). *What do we need for robust, quantitative health impact assessment?* Journal of Public Health Medicine 23: 173-178.

Mosse M, Sontheimer LE (1996). *Performance monitoring indicators handbook*. World Bank Technical Paper No. 334. Washington, D.C., U.S.: The World Bank.

Prüss-Üstün A, Bonjour S, Corvalan C (2008). *The impact of the environment on health by country: a meta-synthesis*. Environmental Health 7: 10.

Randrianasolo L, Raoelina Y, Ratsitorahina M, Ravolomanana L, Andriamandimby S, Heraud JM, Rakotomanana F, Ramanjato R, Randrianarivo-Solofoniaina AE, Richard V (2010). *Sentinel surveillance system for early outbreak detection in Madagascar*. BMC Public Health 10: 8.

Rey P (2008). *Etude de base socio-économique: état de référence*. Montreal, Canada: La Granada Enterprises Ltd. (unpublished document).

Rio Tinto (2010). *Official website of the Rio Tinto Simandou project*. Conakry, Republic of Guinea: Rio Tinto Simfer SA [http://www.riotintosimandou.com/; accessed: 24 September 2011].

Schellenberg JA, Victora CG, Mushi A, de Savigny D, Schellenberg D, Mshinda H, Bryce J, for the Tanzania Integrated Management of Childhood Illness MCE Baseline Household Survey Study Group (2003). *Inequities among the very poor: health care for children in rural southern Tanzania*. Lancet 361: 561-566.

Scott-Samuel A (1998). *Health impact assessment: theory into practice*. Journal of Epidemiology and Community Health 52: 704-705.

SNC-Lavalin (2009). *Social and environmental baseline study Simandou mining area*. Montreal, Canada: SNC-Lavalin (unpublished document).

Thamlikitkul V (2006). *Bridging the gap between knowledge and action for health: case studies*. Bulletin of the World Health Organization 84: 603-607.

Turner AG, Magnani RJ, Shuaib M (1996). *A not quite as quick but much cleaner alternative to the expanded programme on immunization (EPI) cluster survey design*. International Journal of Epidemiology 25: 198-203.

United Nations (2008). *Designing household survey samples: practical guidelines*. New York, U.S.: Department of Economic and Social Affairs. United Nations Publication.

Utzinger J, Keiser J (2006). *Urbanization and tropical healt - then and now*. Annals of Tropical Medicine and Parasitology 100: 517-533.

Utzinger J, Wyss K, Moto DD, Yemadji N, Tanner M, Singer BH (2005). *Assessing health impacts of the Chad-Cameroon petroleum development and pipeline project: challenges and a way forward*. Environmental Impact Assessment Review 25: 63-93.

Veerman JL, Barendregt JJ, Mackenbach JP (2005). *Quantitative health impact assessment: current practice and future directions*. Journal of Epidemiology and Community Health 59: 361-370.

WHO (1999). *WHO recommended surveillance standards, 2nd edition. WHO/CDS/CSR/ISR/99.2*. Geneva, Switzerland: World Health Organization.

WHO (2009). *Short guides for health impact assessment*. Geneva, Switzerland: World Health Organization [http://www.who.int/hia/about/guides/en/; accessed: 24 September 2011].

Winkler MS, Divall MJ, Krieger GR, Balge MZ, Singer BH, Utzinger J (2010). *Assessing health impacts in complex eco-epidemiological settings in the humid tropics: advancing tools and methods*. Environmental Impact Assessment Review 30: 52-61.

Winkler MS, Divall MJ, Krieger GR, Balge MZ, Singer BH, Utzinger J (2011). *Assessing health impacts in complex eco-epidemiological settings in the humid tropics: the centrality of scoping*. Environmental Impact Assessment Review 31: 310-319.

5. Barbarians at the gate: storming the Gothenburg consensus

Gary R. Krieger[a], Jürg Utzinger[b,c*], Mirko S. Winkler[b,c], Mark J. Divall[d], Scott D. Phillips[a], Marci Z. Balge[a], Burton H. Singer[e],

[a] NewFields, LLC, Denver, CO 80202, USA

[b] Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, P.O. Box, CH-4002 Basel, Switzerland

[c] University of Basel, P.O. Box, CH-4003 Basel, Switzerland

[d] NewFields, LLC, Pretoria 0062, South Africa

[e] Emerging Pathogens Institute, University of Florida, Gainesville, FL 32610, USA

* Corresponding authors. Prof Gary R Krieger, NewFields, LLC, Denver, CO 80202, USA, Tel.: +1 303 294-0950; Fax: +1 303 294-9220; *E-mail address:* gkrieger@newfields.com, and Prof Jürg Utzinger, Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, CH-4002 Basel, Switzerland, Tel.: +41 61 284-8129; Fax: +41 61 284-8105; *E-mail address:* juerg.utzinger@unibas.ch

This article has been published in:

Lancet 2010, 375: 2129-2131

The concept, techniques, and applications of health impact assessment (HIA) hold promise to raise the profile of health within the overall project, policy and programme planning, and assessment cycle (Kemm et al., 2004). HIA in the public sector has progressed over the past two decades with a strong Eurocentric focus on transportation and social programmes and policies. In 1999, the publication of the Gothenburg consensus from WHO's European Centre for Health Policy (ECHP) further enhanced the visibility of HIA, but achieved little to put its high ideals into operation (WHO/ECHP, 1999). By contrast, the private sector HIA has had a more focused history, with an emphasis on large industrial projects in the developing world with rigorous adherence to assessment protocols. Has the post-Gothenburg HIA movement expanded beyond being Eurocentric and moved towards a global perspective? These considerations are relevant for the alignment and implementation of HIA protocols between the private and public sectors, which have seemingly developed in different universes (Figure 5.1).

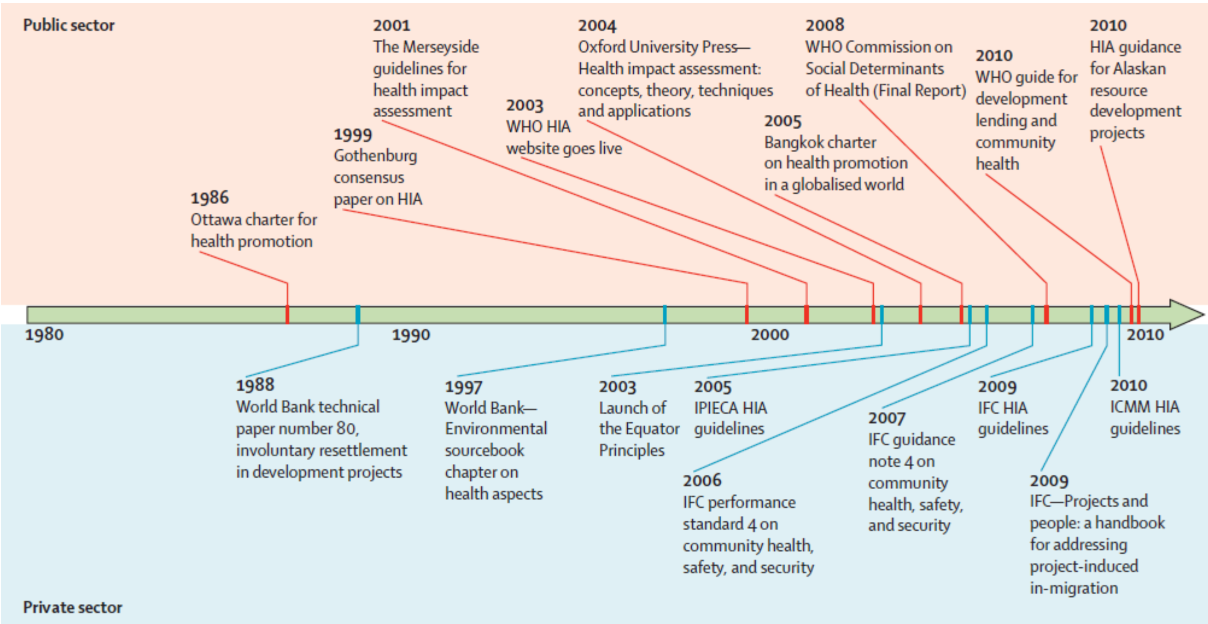


Figure 5.1: Landmarks of HIA, stratified by public and private sector.
(HIA = health impact assessment. ICMM = International Council on Mining and Metals. IFC = International Finance Corporation. IPIECA = International Petroleum Industry Environmental Conservation Association.)

In 1999, the Gothenburg HIA framework stated that, in addition to promoting the maximum health of the population, four values would be emphasised: democracy, equity, sustainable development, and ethical use of evidence (WHO/ECHP, 1999). Equity considerations would be ultimately incorporated into the Gothenburg-driven HIA model by a wholesale embrace of the work of WHO's Commission on Social Determinants of Health (CSDH) (WHO/CSDH, 2008). Hence the Gothenburg consensus fused with CSDH and produced an HIA methodology that was mainly based on the social determinants of health model, which was initially developed in the early 1990s (Dahlgren and Whitehead, 1992). This HIA movement further accelerated a growing number of scholarly articles on HIA (Scott-Samuel, 1996; Lerer, 1999; Douglas et al., 2001). The geographical concentration of the published work, however, was mainly centred on the industrialized world (Erlanger et al., 2008). Quietly and in parallel, a more focused and limited set of HIA processes and procedures was being developed by both the private sector and the International Finance Corporation (IFC). IFC's health methodology is based on results that show that almost half of measurable health improvement in sub-Saharan Africa was unrelated to the health system itself, but rather caused by improvements in the housing, water, sanitation, transportation, and communication sectors (Listorti and Doumani, 2001). This type of strategy that links environment and health is appealing to private industrial corporations and major financial institutions, because it capitalises on engineering and logistical skills inherent to industrial projects while avoiding the placement of private companies in the de-facto role of ministry of health. In the industrial context, IFC's performance standard framework has been made operational and has been adopted by a large consortium of multilateral lending institutions known as the Equator Principles Financial Institutions (EPFIs). The EPFIs incorporate IFC's performance standards as part of loan covenants, thereby creating a clear mechanism of enforcement (IFC, 2006).

The WHO CSDH framework emphasises policies at national level with correspondingly broad-based impact assessment and mitigation. By contrast, the private sector highlights impacts and mitigation only for communities in which causal links between community and project impact are anticipated. The implementation of CSDH aspirations lies in the future, whereas, at present, the private sector projects are creating tangible results on the ground. As the scramble for access to natural resources in the developing world accelerates (Shannon et al., 2008), the tension between the two approaches increases, particularly for host communities in developing countries.

Meanwhile, the growing effect of Chinese direct investment in extractive industry projects in developing countries is becoming an important but largely unspoken driver of the overall developmental model debate (Bosshard, 2008). Chinese investments, at present, do not come with sufficient requirements on environmental, health, and social impact assessment. The competition for financing infrastructure and extractive industry projects is intense, and places adherents to IFC's performance standards at a potential competitive disadvantage. However, at real issue is the focus of the health assessment and the subsequent ability of the government or corporation to avoid, eliminate, or mitigate negative effects, and enhance positive project benefits and opportunities, without simultaneously marginalising the project economically.

The methodological battle for the hearts and minds of individuals, private companies, and ministries of health is ongoing. The aspirational HIA discourse, stemming from the 1999 Gothenburg consensus and WHO's CSDH, directs attention away from solvable issues in which the private sector can make a difference. The overall HIA initiative is at a tipping point. The wholesale adoption of CSDH definitions and methodologies for HIA in industrial projects of the developing world is neither desirable nor ultimately beneficial for host communities.

The large multilateral lending institutions have taken a step in moving health to centre stage. There is still an available window to establish a workable framework that major multilateral financial institutions, countries hungry for resources, and international health agencies can and should seize. To be accepted as a fully functional member of the impact-assessment process, HIA must move beyond the aspirational rhetoric of Gothenburg and become a practical operational tool and method that can be embraced by all of the key stakeholders.

5.1. Acknowledgement

Jürg Utzinger acknowledges financial support from the Swiss National Science Foundation (project number PPOOB-102883, PPOOB-119129).

5.2. Conflict of interest

We have done work for the private sector, development banks, and multinational organisations, and served as experts on WHO committees and for other international organisations.

5.3. References

Bosshard P (2008). *China's environmental footprint in Africa*. Johannesburg, South Africa: China in Africa Project of the South African Institute of International Affairs (SAIIA).

Dahlgren G, Whitehead M (1992). *Policies and strategies to promote social equity in health*. Copenhagen, Sweden: WHO Regional Office for Europe.

Douglas MJ, Conway L, Gorman D, Gavin S, Hanlon P (2001). *Developing principles for health impact assessment*. Journal of Public Health Medicine 23: 148-54.

Erlanger TE, Krieger GR, Singer BH, Utzinger J (2008). *The 6/94 gap in health impact assessment*. Environmental Impact Assessment Review 28: 349-358.

IFC (2006). *Performance standards*. Washington, D.C., U.S.: International Finance Corporation [http://www.ifc.org/ifcext/sustainability.nsf/Content/PerformanceStandards; accessed: 9 May 2011].

Kemm J, Parry J, Palmer S (2004). *Health impact assessment: concepts, theory, techniques, and applications*. Oxford, U.K.: Oxford University Press.

Lerer LB (1999). *Health impact assessment*. Health Policy and Planning 14: 198-203.

Listorti JA, Doumani FM (2001). *Environmental health: bridging the gaps. World Bank discussion paper No. 422*. Washington, D.C., U.S.: The World Bank Group.

Scott-Samuel A (1996). *Health impact assessment: an idea whose time has come*. BMJ 313: 183-184.

Shannon MA, Bohn PW, Elimelech M, Georgiadis JG, Mariñas BJ, Mayes AM (2008). *Science and technology for water purification in the coming decades*. Nature 452: 301-10.

WHO/CSDH (2008). *Closing the gap in a generation: health equity through action on the social determinants of health*. Geneva, Switzerland: World Health Organization.

WHO/ECHP (1999). *Health impact assessment: main concepts and suggested approach. Gothenburg consensus paper*. Copenhagen, Sweden: WHO Regional Office Europe.

5.4. Correspondence – New international consensus on health impact assessment

Salim Vohra[a,*], Ben Cave[b], Francesca Viliani[c], Ben F Harris-Roxas[d], Rajiv Bhatia[e]

[a] Centre for Health Impact Assessment, Institute of Occupational Medicine (London Office), Research House Business Centre, London UB6 7AQ, UK

[b] Ben Cave Associates, Leeds, UK

[c] International SOS, Copenhagen, Denmark

[d] Centre for Primary Health Care and Equity, University of New South Wales, Sydney, NSW, Australia

[e] San Francisco Department of Public Health, San Francisco, CA, USA

* Corresponding author. Dr. Salim Vorah, Centre for Health Impact Assessment, Institute of Occupational Medicine (London Office), Research House Business Centre, London UB6 7AQ, UK, *E-mail address:* salim.vohra@iom-world.org

This correspondence has been published in:

Lancet 2010, 376: 1464-1465

Gary Krieger and colleagues (June 19, p 2129) (Krieger et al., 2010) present a polarising narrative, pitting themselves, as private sector consultants, against health impact assessment (HIA) as conceptualised in the Gothenburg Consensus. Krieger and colleagues represent one per spective among HIA practitioners, who all share a commitment to the protection and enhancement of health and wellbeing (Harris-Roxas and Harris, 2011).

The private sector's use of HIA has not evolved independently of the public sector. Krieger and colleagues omit to note that the International Finance Corporation is a government-owned entity. Demand by governments for the accountability of financial institutions has been a driver for the private sector's use of impact assessment, including HIA. The interplay between public and private sectors has led to guidance for, and commissioning of, HIA. Krieger and colleagues also do not acknowledge their role in writing the International Finance Corporation guidance for HIA (IFC, 2009).

The environmental health areas framework (Listorti and Doumani, 2001) and the social determinants of health (WHO/CSDH, 2008) are not incompatible approaches. Public health is best served by acknowledging the dynamic between environmental and social factors, and reflecting this in integrated analysis – an approach common to most HIA practice including that articulated by the environmental health areas framework.

Krieger and colleagues write that the operationalisation of HIA is the key. We state that transparency, accountability, and having a wide scope are also crucial to achieving the promise of "tangible results" from large projects. We do not agree with Krieger and colleagues' Comment, but welcome their contribution. We call on them, and others, to come together to develop a post-Gothenburg international HIA consensus that moves the field forward.

5.5. Conflict of interest

We have done HIA-related work for the private sector, various government agencies, development banks, and multinational organisations, and have served as experts at WHO.

5.6. References

Harris-Roxas B, Harris E (2011). *Differing forms, differing purposes: a typology of health impact assessment*. Environmental Impact Assessment Review 31: 396-403.

IFC (2009). *Introduction to health impact assessment*. Washington, D.C., U.S.: International Finance Corporation [http://www.ifc.org/ifcext/sustainability.nsf/Content/Publications_Handbook_HealthImpactAssessment; accessed: 9 May 2011].

Krieger GR, Utzinger J, Winkler MS, Divall MJ, Phillips SD, Balge MZ, Singer BH (2010). *Barbarians at the gate: storming the Gothenburg consensus*. Lancet 375: 2129-2131.

Listorti JA, Doumani FM (2001). *Environmental health: bridging the gaps. World Bank discussion paper No. 422*. Washington, D.C., U.S.: The World Bank Group.

WHO/CSDH (2008). *Closing the gap in a generation: health equity through action on the social determinants of health*. Geneva, Switzerland: World Health Organization.

5.7. Authors' reply

We appreciate the points offered by Salim Vohra and colleagues. Yet we strongly disagree with their perspective, justified on the following grounds.

First, our Comment was centred on the need to clarify important distinctions between private sector projects and government-sponsored policies, programmes, and projects, which are currently being conflated. The field of health impact assessment (HIA) is being wrapped in a cloak of aspirational social determinants rhetoric, which fosters a misperception of universality of this framework and its implementation. The social determinants movement has an important objective to identify and potentially alleviate social in equalities. Although worthy, this is not the role and responsibility of a private company. Our key point is to recognise the aspects of a project that the private sector can directly affect. As part of a project, key core competencies (e.g., engineering and logistics) of the private sector can be selectively focused to avoid or mitigate negative health effects and enhance positive ones.

The International Finance Corporation (IFC) HIA toolkit recognises the link between broadly defined environ mental health and the burden of diseases in the developing world (Prüss-Üstün et al., 2008). It therefore builds on pioneering work by the World Bank (Listorti and Doumani, 2001), supported by contemporary HIA in developing countries (Krieger et al., 2008; Winkler et al., 2010). We believe that it is a mistake to embed HIA for large industrial projects, and subsequent local community follow-up, in a discussion of social issues that no private-sector project can realistically and sustainably manage.

Second, Vohra and colleagues reveal a misreading of the development of the Equator Principles, which are a voluntary set of standards for the identification, assessment, and management of social and environmental risk in project financing. Describing the history of the Equator Principles as a "demand" by governments for financial institutions' "accountability" is simply not correct (Heal, 2008).

Third, our group was indeed commissioned by the IFC to develop technical guidance for HIA. We stated in our conflict of interest statement that we had done work for "the private sector, development banks, and multinational organisations". We apologise if this did not explicitly mention the IFC. Similar to other private sector and multinational organisations, IFC has a rigorous process for vetting and reviewing guidance materials. Our contribution went through exhaustive stakeholder consultation and extensive review by IFC's in-house technical experts and IFC retained editorial control of the process and final product.

Finally, we agree that transparency, accountability, and having a wide scope – along with operationalisation – are key issues to move the field of HIA forward. A post-Gothenburg international HIA consensus is critical, but this requires clarity about the distinctions between HIA done as part of nationally focused government initiatives, and those accompanying private-sector projects with only local community effects.

5.8. Conflict of interest

We have done work for the private sector, development banks, and multinational organisations, including the IFC, and have served as experts on WHO committees and for other international organisations.

5.9. References

Heal GM (2008). *When principles pay: corporate social responsibility and the bottom line*. New York, U.S.: Columbia University Press.

Krieger GR, Balge MZ, Chanthaphone S, Tanner M, Singer BH, Fewtrell L, Kaul S, Sananikhom P, Odermatt P, Utzinger J (2008). *Nam Theum 2 hydroelectric project, Lao PDR*. In: Fewtrell L, Kay D, editors. Health impact assessment for sustainable water management. London, U.K.: IWA Publishing pp. 199-232.

Listorti JA, Doumani FM (2001). *Environmental health: bridging the gaps. World Bank discussion paper No. 422*. Washington, D.C., U.S.: The World Bank Group.

Prüss-Üstün A, Bonjour S, Corvalan C (2008). *The impact of the environment on health by country: a meta-synthesis*. Environmental Health 7: 7.

Winkler MS, Divall MJ, Krieger GR, Balge MZ, Singer BH, Utzinger J (2010). *Assessing health impacts in complex eco-epidemiological settings in the humid tropics: advancing tools and methods*. Environmental Impact Assessment Review 30: 52-61.

6. Discussion

The main purpose of this PhD thesis was to develop a systematic approach for health impact assessment (HIA) that is aligned to manage the many factors of typical tropical country contexts, placing particular emphasis on industrial development projects. Existing methods were advanced and new tools created, all of which were broadly validated in the frame of HIA assignments, primarily in sub-Saharan Africa. In this process a 'HIA-trilogy' (chapters 2-4) emerged, presenting a methodology for HIA in complex eco-epidemiological settings in the humid tropics. Exemplified by case studies, the HIA practitioner is guided through different stages of the overall HIA process, familiarised with the particularities of a developing country context and introduced to well-defined tools for data collection, management and analysis (see Figure 6.1) (Winkler et al., 2010, 2011, 2012).

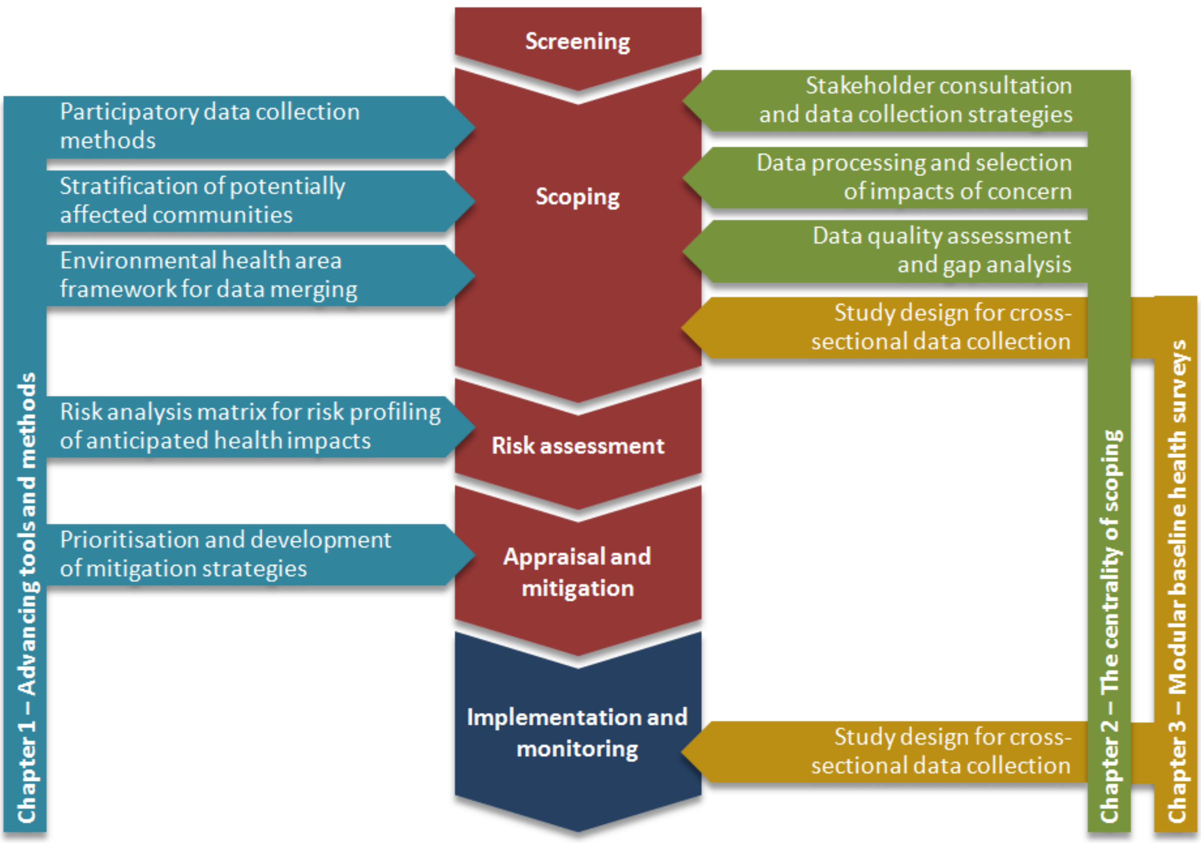


Figure 6.1: The different chapters of the 'HIA-trilogy' and their methodological contributions to the HIA process in developing country setting.

In the current chapter, the presented tools and methods will not be further discussed as this was done in detail in the respective parts of the 'HIA-trilogy'. Instead, against the background of experiences gained in the frame of this PhD thesis, future challenges of HIA in the developing world will be critically examined and further discussed. At first, the driving forces for HIA in developing countries will be pointed out, including the current burden of disease and major drivers of global change, followed by an assessment of the potential of HIA in the developing world and insights into current practice. Finally, options for the further promotion of HIA, with a particular focus on the African Region, are explored and specific recommendations made.

6.1. The driving forces for HIA in developing countries

Besides a set of case studies – including chapter 2-4 of the present PhD thesis – only few scholarly articles with a particular focus on the institutional and methodological context of HIA in developing countries exist, namely (i) Birley (2004) and (ii) Erlanger (2008). However, the scantly literature currently available on this topic has one feature in common: it emphasises the prominent differences between HIA in the industrialised world and developing countries. The understanding of these disparities is the basis for the exploration of ways for the further promotion of HIA on a global scale, including developing countries in Southeast Asia and sub-Saharan Africa.

6.1.1. Burden of disease and underlying risk factors

With the aim to provide a comprehensive assessment of the burden of diseases and injuries in the world and eight major regions, the World Bank initiated the first Global Burden of Disease (GBD) study in the early 1990s (World Bank, 1993; Murray et al., 1994). For this purpose, a new indicator, the number of disability-adjusted life years (DALYs), was introduced, which expresses the number of years lost due to ill-health, disability or premature death (Murray, 1996). In the year 2000, the World Health Organization (WHO) began publishing regular GBD updates for the world and 14 WHO regions and is currently working on the GBD 2010 study (WHO, 2011a). The latest assessment of the GBD is the 2004 update, which will be used here for investigating the burden of disease in relation to gross national income per capita (WHO, 2008a; World Bank, 2011).

The 10 leading causes of burden of diseases in high-income countries (population ~1 billion) and low-income countries (population ~2.5 billion), which account for a total of 49.3 million DALYs and 380.0 million DALYs, respectively, are shown in Table 6.1 (WHO, 2008a). Based on this statistic, two major differences between high- and low-income countries become obvious: (i) under consideration of the different population sizes, the burden of disease in low-income countries is three times higher when compared to high-income countries; and (ii) the world can be divided in two groups – those in which the burden of disease is dominated by vascular disease and depression, and those in which the burden of disease is dominated by communicable disease. These realities are also reflected by the fact that people in high-income countries live, on average, 21 years longer than people in low-income countries (WHO, 2008b).

High-income countries		Low-income countries	
Causes of burden of disease	DALYs in millions	Causes of burden of disease	DALYs in millions
Unipolar depressive disorders	10.0	Lower respiratory infections	76.9
Ischaemic heart disease	7.7	Diarrhoeal diseases	59.2
Cerebrovascular disease	4.8	HIV/AIDS	42.9
Alzheimer and other dementias	4.4	Malaria	32.8
Alcohol use disorders	4.2	Prematurity and low birth weight	32.1
Hearing loss, adult onset	4.2	Neonatal infections and others	31.4
Chronic obstructive pulmonary disease	3.7	Birth asphyxia and birth trauma	29.8
Diabetes mellitus	3.6	Unipolar depressive disorders	26.5
Trachea, bronchus, lung cancers	3.6	Ischaemic heart disease	26.0
Road traffic accidents	3.1	Tuberculosis	22.4
Total	49.3	Total	380.0

Table 6.1: The 10 leading causes of burden of disease in high- and low-income countries expressed in disability-adjusted life years (DALYs) (adapted from WHO (2008a)).

When considering possible health impacts and interventions, it is important to know the factors that raise the probability of adverse health outcomes, i.e. health risks (von Schirnding, 2002; Moore et al., 2003; Ezzati et al., 2005). While for most distal risk factors, such as education and income, less causal certainty can be attributed to each risk, this is different for distinct environmental, behavioural and physiological determinants. Based on work done by Ezzatti and colleagues (2002; 2004), the WHO recently published a report on global health risks that describes mortality and burden of disease attributable to 24 specific risk factors (WHO, 2009a). The estimated proportion of total DALYs in low- and high-income countries attributable to 6 distinct health risk factor groups is summarised in Table 6.2. Of note, as risks may act in part through, or jointly with other risks, the DALYs attributable to health risk factor groups is usually an over estimate. In fact, it was concluded that globally 34% of DALYs (and 44% of global deaths) can be attributed to those 24 health risk factors, which is less than the sum of individual risks (51.4%) (WHO, 2009a).

	High-income countries	Low-income countries
Health risk factor groups	Percentage of DALYs	Percentage of DALYs
Childhood and maternal under-nutrition	1.0	19.6
Environmental risks	1.2	11.9
Unhealthy diet and physical inactivity	26.6	8.4
Addictive substance abuse	19.7	4.2
Sexual and reproductive health	0.9	7.3
Others	2.3	2.3

Table 6.2: Estimated disability-adjusted life years (DALYs) attributable to health risk factor groups (adapted from WHO (2009a)).

Although the total amount of DALYs attributable to specific health risk factors is similar, the composition of major health risks is different among world regions. In a tropical context, the most important health risk factor groups are childhood and maternal under-nutrition (e.g. underweight, micronutrient deficiencies and sub-optimal breastfeeding) as well as environmental risks (e.g. unsafe water, sanitation, hygiene, indoor smoke from solid fuels and global climate change). Major health risks in industrialised countries are unhealthy diet and physical inactivity, followed by addictive substance abuse (e.g. alcohol and tobacco), all of which have a strong behavioural component (WHO, 2009a).

6.1.2. Health inequalities and social determinants of health

It is well established that health follows a social gradient: better health with increasing socio-economic status due to a higher housing standard, better access to education and healthier working conditions (Victora et al., 2003; Graham, 2007). Socio-economic disparities also determine differential access to, and use of health care, with a substantial effect on prevention, treatment, and survival (Adler et al., 1994; Berkman and Kawachi, 2000; Raso et al., 2005). Against this background it becomes apparent that 'health' *per se* is not equally distributed among low-, middle and high-income countries, leading to health inequalities between, but also within countries (Braveman and Tarimo, 2002; Marmot, 2005; Ruger and Kim, 2006). With the aim of achieving health equity, the Commission on Social Determinants of Health (CSDH) called upon the WHO and all governments to lead global action on the social determinants of health (Marmot and CSDH, 2007; WHO/CSDH, 2008). Acknowledging the interdependence of social determinants of health and health equity, three key areas for action were defined (Marmot et al., 2008): (i) improve daily living conditions through improved early child development, gender equity, access to education, better living and working conditions, and social protection policies; (ii) tackle the inequitable distribution of power, money and resources through the promotion of a strong, committed, capable and adequately financed public sector, which requires strengthened governance; and (iii) measure and understand the problem and assess the results of action. It is self-evident that the challenges for health equity are nowhere greater than in developing countries and thus serious action on the social determinants of health is required at all levels.

6.1.3. Population developments and urbanisation

The world's population was estimated at roughly 6.8 billion in 2009, with 5.9 billion people living in less developed regions such as Asia (4.1 billion), Africa (1.7 billion) and Latin America and the Caribbean (0.6 billion) (United Nations, 2010a). The same statistic gives a medium prognosis for 2050 world's population of 9.2 billion (7.9 billion in less developed regions) with varying dimensions of population growth at different latitudes of the globe. By 2050, the population living in temperate zones (above 50° north latitude) is forecasted to have declined by 7% (2007: 0.37 billion, 2050: 0.34 billion), while the population residing in tropical areas of the planet (between 20° north and 20° south latitude) is expected to have raised by 79% (2007: 2.0 billion, 2050: 3.6 billion) (United Nations Population Fund, 2007). These predictions reveal a unilateral population growth in tropical regions of the world and thus an increase in the population living in areas with the highest disease burden (i.e. sub-Saharan Africa and Southeast Asia) (Lopez and Mathers, 2006).

In addition to a growing world population, the world is becoming urban. By 2050, the world's urban population is expected to reach 6.3 billion and thus nearly double from 3.3 billion in 2007 (United Nations, 2010b). Almost all of this growth will be in low- and middle-income regions: in Africa the urban population is likely to triple, and in Asia it will more than double. This exponential urban growth will have profound health implications (McMichael, 2000; Godfrey and Julien, 2005; Utzinger and Keiser, 2006; Alirol et al., 2011): (i) urbanisation will put major pressure on access to safe drinking water, sewerage systems and solid waste management, which is in turn closely related to the transmission of water-, soil-, and waste-related disease; (ii) the urban environment commonly results in changes in human behaviour that affect cardiovascular risk factors and transmission of sexually transmitted infections (STIs), including HIV/AIDS; (iii) high-population densities increase exposure to tuberculosis, measles and influenza; (iv) when cities emerge, vector-ecology is changed, which alters existing, or introduces new vector-related diseases; (v) more people will be exposed to traffic-related air and noise pollution; and (vi) important socio-economic disparities may emerge in urban centres, resulting in profound health inequalities.

On the other hand, due to an improved socio-economic status and ready access to health care, health conditions are, on average, better in urban areas than in rural areas in the developing world (Dye, 2008). In industrialised nations, urbanisation has contributed to an overall improvement of health, accompanied by a major shift in disease patterns towards a rise in chronic diseases (Beaglehole and Yach, 2003; Prentice, 2006; Miranda et al., 2008). However, there is fundamental divide between the long process of urbanisation in industrialised western nations and the relatively recent explosive expansion in resource-poor countries. A formidable challenge lies ahead as countries in tropical areas will not only have to significantly increase the capacities of their health delivery system in order to cope with a growing population but also continuously adapt health-related policies and programmes to a changing disease pattern (Jamison et al., 2006; WHO, 2010; Viner et al., 2011).

6.1.4. The need for natural resources

A growing world population will, of necessity, lead to a raised demand in mineral and energy resources. Due to construction activities, technology and wealth increase, particularly in developing countries, strong demand will be created across the entire spectrum of industrial metals. It was estimated that the overall metal flow into use in 2050 will be 5–10 at times today's level (Graedel and Cao, 2010). To cover the global energy needs is a major challenge already today and, according to the U.S. Energy Information Agency (USEIA), will even become worse. The world marketed energy consumption is estimated to increase by 49% from 2007 to 2035, with a total energy demand increase of over 80% in the Asia Pacific Region, Latin America and sub-Saharan Africa (USEIA, 2010).

The developing world has enormous potential for covering future mineral resources and energy demands. In fact, with gold, diamonds, bauxite, cobalt, phosphate rock, coltan, platinum-group metals, vermiculite and zirconium, Africa is home to some of the largest remaining deposits of mineral resources in the world (Yager et al., 2007). The extent of the potential energy resources in developing countries is reflected by the World Energy Investment Outlook 2003: over the period 2001-2030, the total investment requirement for energy supply infrastructure worldwide was estimated at US$ 16 trillion, or US$ 550 billion a year. Almost half of total energy investment, or US$ 7.9 trillion, will take place in developing countries and 10% (US$ 1.7 trillion) in the transition economies (International Energy Agency (IEA), 2003). Although the global energy supply will continue to be covered to a great extent by fossil fuels, also renewable energy sources such as hydropower, large-scale biomass energy, solar conversion and wind energy are gaining terrain (Bilgen et al., 2004; Kjärstad and Johnsson, 2009; USEIA, 2010). This development might be further accelerated by the recent nuclear power plant accident at Fukushima Daiichi in Japan, which led to a re-evaluation of existing nuclear energy programmes all over the world (Butler, 2011; Forbes, 2011; Science News Staff, 2011). As for fossil fuels, alternative energy technologies have huge potential in the developing world, including all its opportunities and risks (Karekezi, 2002; Varis, 2007; Kline and Dale, 2008; Scharlemann and Laurance, 2008; Brew-Hammond, 2010; Liaquat et al., 2010; Amigun et al., 2011).

These statistics regarding the need for natural resources are not only vague predictions but already a reality the world over. For example, the highest growth rate in the least developed countries during the period 2000-2006 was evident in the non-manufacturing sector, including, in particular, mining industries, the exploitation of crude oil and construction activities (United Nations, 2008). Of note, there were significant differences amongst the sectoral growth rates in low-income countries in Asia and Africa. The leading sector in terms of growth rate in Asia was the manufacturing industry, which is estimated to have grown by 8% during the present decade. In Africa, the leading sector was non-manufacturing industrial activities, with an average annual growth rate of 10.3% per annum. Moreover, the pick-up in demand for natural resources is also clearly visible in the commodities market with rising energy, natural minerals and food prices over the past years (International Monetary Fund (IMF), 2010).

6.1.5. Climate change

It is widely acknowledged that the increase in atmospheric greenhouse gases due to emissions from fossil fuel combustion, ozone depletion, animal agriculture, deforestation and many other factors influence the world's climate (Karl and Trenberth, 2003; Parmesan and Yohe, 2003; Lal, 2004). Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, which is likely to affect the health status of millions of people, particularly those with low adaptive capacity (Intergovernmental Panel on Climate Change (IPCC), Patz et al., 2005; 2007; Climate and Health Council, 2011). Documented and anticipated health effects include (Brooks and Hoberg, 2007; Costello et al., 2009; Dobson, 2009; WHO, 2009b; Zhao and Running, 2010; Myers and Bernstein, 2011; Sheffield and Landrigan, 2011):

- increasing levels of malnutrition and consequent disorders, with severe implications for child growth and development;
- alteration in the distribution of malaria, dengue fever, schistosomiasis and other diseases transmitted by insect vectors or those that have animal reservoir hosts;
- increasing burden of diarrhoeal and respiratory disease;
- increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone;
- heat-related health effects on school performance and pregnancy complications; and
- increased deaths, disease and injury due to floods, storms, heatwaves, droughts and fires.

Substantial variation in these outcomes is evident by geographic region and socio-economic status, and thus an exacerbation in health disparities is likely (Figure 6.2) (McMichael and Butler, 2004; Patz et al., 2007; Friel et al., 2008; Costello et al., 2009; Lafferty, 2009; Yang et al., 2010; Spickett et al., 2011a). The final common pathway for many of the climate change impacts will be population displacement. It is anticipated that by 2050 an estimated 200 million, and perhaps up to 1 billion people, may be displaced due to climate change (Myers and Bernstein, 2011). However, there are enormous uncertainties surrounding these predictions with regard to how climate change may affect human well-being, and considerable work is required to address key issues of quantification and mitigation of the climate-health associations. This will include frameworks that can serve as comprehensive decision-support tools for the incorporation of climate change preparedness strategies into public health programmes and policies, such as HIA (Frumkin et al., 2008; Patz et al., 2008; Haines et al., 2009; Sheffield and Landrigan, 2011; Spickett et al., 2011b).

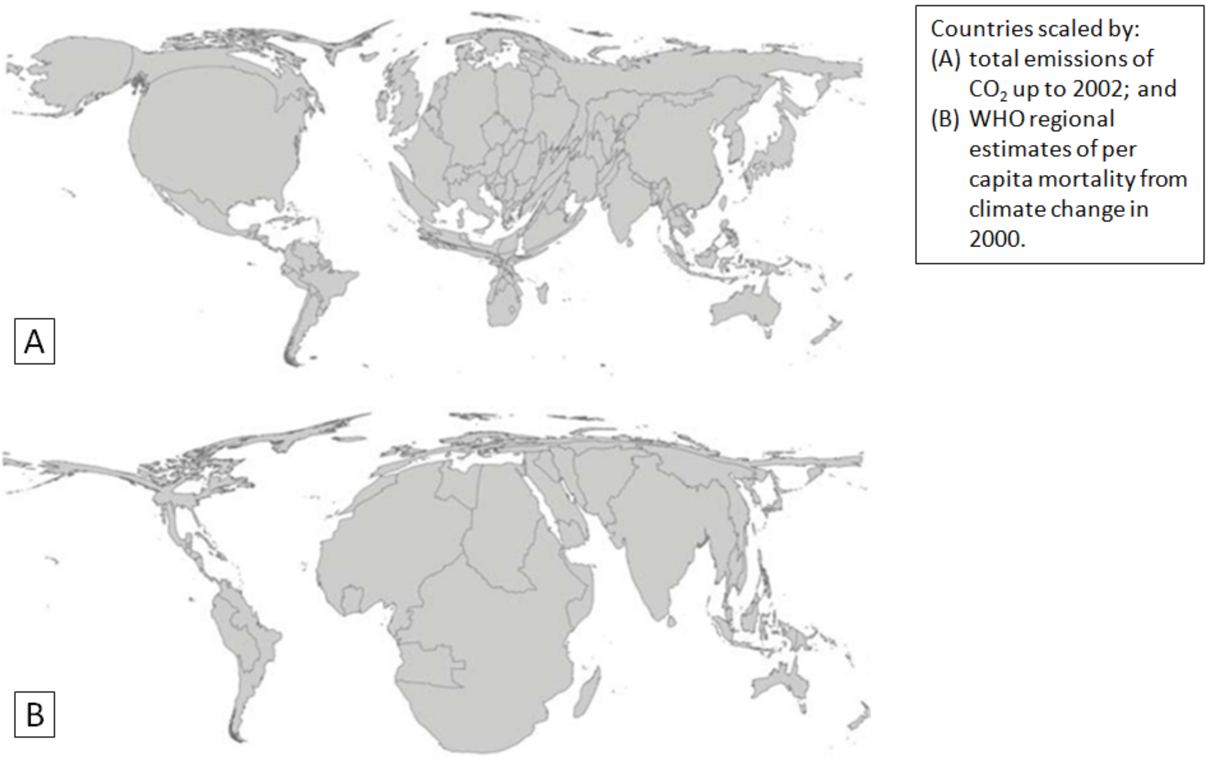


Figure 6.2: Poorer countries contribute little to carbon dioxide (CO_2) emissions, but are most vulnerable to health impacts due to climate change (Source: map projections by Patz et al. (2007)).

6.2. The need for HIA in the developing world

As outlined in the previous sections, developing countries in tropical regions do not only have the highest burden of disease and health inequalities but are also most affected by three major drivers of global change of the 21st century: (i) population growth and urbanisation; (ii) increasing demand in natural resources; and (iii) regional climate change. The magnitude and range of anticipated adverse health impacts due to this critical combination is alarming. It is thus evident that modification of existing, and development of new policies, programmes and projects in various sectors on different levels will be essential: (i) population growth and urbanisation necessitate urban, regional and traffic planning as well as adaption to changing disease patterns and frequencies at the level of health programmes and policies (McMichael, 2000; Godfrey and Julien, 2005; Utzinger and Keiser, 2006; Hughes and Kemp, 2007; Vohra, 2007; Dye, 2008; Alirol et al., 2011); (ii) increasing pressure on natural resources results in a booming extractive and renewable energy industry with a variety of implications at local, national and regional scale (Lerer and Scudder, 1999; Jobin, 2003; Utzinger et al., 2005; Krieger et al., 2008); and (iii) in order to cope with a changing environment, many countries will have to incorporate predictions about global climate change into their programmes, policies and planning of infrastructure developments (McMichael and Butler, 2004; Frumkin et al., 2008; Patz et al., 2008; WHO, 2009b; Spickett et al., 2011b). Hence, each of the predicted drivers of global change will either act through or be influenced by policies, programmes and projects as illustrated in Figure 6.3. HIA as a combination of procedures, methods and tools that systematically judges the potential effects of a policy, programme or project on the health of a population has thus, without any doubt, enormous potential to assist decision-making for health promotion in the developing world.

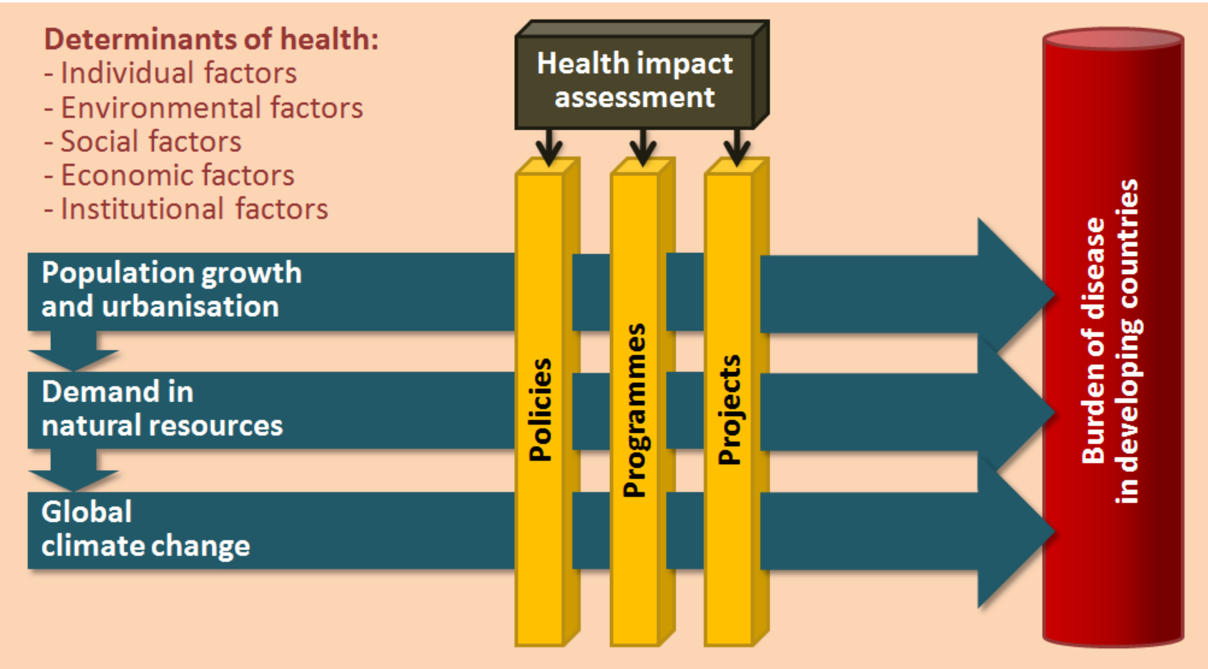


Figure 6.3: The potential of HIA as decision-making tool for policies, programmes and projects for the mitigation of adverse health effects due to major drivers of global change.

6.3. Current HIA practice in developing countries

HIA practice is in stark contrast to the identified need for HIA in developing countries. For example, the number of low-income (i.e. annual per capita income US$ 995 or less; $n = 40$) and lower-middle-income countries (i.e. annual per capita income US$ 995-US$ 3,945; $n = 56$) having a regulatory requirement for HIA is only three (i.e. Thailand, India and Lao People's Republic), all of which are from Southeast Asia (World Bank, 2011; Harris-Roxas, 2011). Equally, Erlanger and colleagues (2008) found that only 6% of the peer-reviewed literature pertaining to HIA had an explicit focus on developing countries (1976 to May 2007).

With the goal to grasp the most recent developments at the HIA front, an update of this systematic literature review was performed, using identical search criteria and procedures. It was found that 208 new HIA-related articles were published in the peer-reviewed literature for the time span from June 2007 to May 2011. The temporal analysis of all publications on HIA reveals that the exponential growth of HIA literature is continuing, with almost half of the articles that were published in the past four years (1976-1990: 7 contributions (1.6%); 1991-2000: 45 contributions (9.9%); 2001-May 2007: 185 contributions (40.7%); and June 2007-May 2011: 208 (45.7%)). In 2007, 15 (6%) of the identified publications had a focus on low- and middle-income countries. During the past four years, it was 20 out of the 208 records, which equates 9.6%. Thus, the 6/94 gap in HIA identified by Erlanger et al. (2008) has shrunken by almost 2%, leading to the conclusion that today approximately 8% of the peer-reviewed literature pertains to HIA in developing countries. This is good news as it implies a higher acceleration in HIA-related publications with a focus on developing countries compared to the average. In fact, when comparing the total number of HIA-related articles published from January 2001-May 2007 ($n = 185$) and from June 2007-May 2011 ($n = 208$), there was an increase of 112.4%. The same calculation with only articles pertaining to developing countries reveals a growth of 222.2% (2001-May 2007 ($n = 9$); June 2007-May 2011 ($n = 20$)) as illustrated in Figure 6.4.

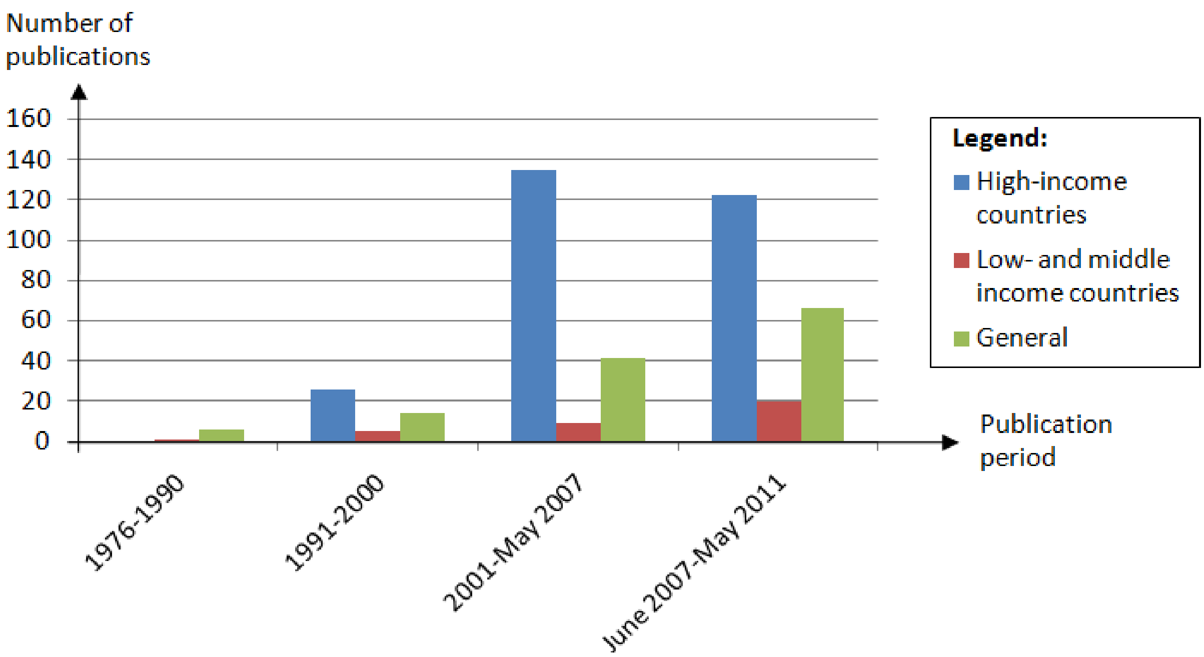


Figure 6.4: Number of HIA-related publications in the peer-reviewed literature between 1976 and May 2011, stratified by whether the publication has a focus on either high-income countries, low- and middle-income countries, or general.

Regarding the content of the published articles, 19 of all the HIA-related publications with a focus on developing countries dealt specifically with policies (*n* = 2; 10.5%), programmes (*n* = 5; 26.3%) or projects (*n* = 12; 63.2%). In industrialised countries, more than half of the proposal oriented publications deal with policies (Erlanger et al., 2008).

In summary, when using the number of countries having a regulatory requirement for HIA, or the amount of HIA-related scholarly articles, as proxy for HIA practice, we can draw the following picture: in the developing world, HIA is still poorly practiced, though, there is an increasing interest in HIA, particularly in Southeast Asia. Furthermore, there appears to be a focus on HIA of industrial development projects in the developing world compared to policies and programmes in industrialised countries. However, the current burden of disease in tropical regions and future predictions about adverse health impacts of population growth and urbanisation, demand in natural resources and global climate change impose the question: what can be done to rapidly and sustainably promote HIA practice in the developing world?

6.4. How to promote HIA in the developing world: a bottom-up approach

The following parameters were identified as cornerstones for the promotion and strengthening of HIA practice in developing countries (Caussy et al., 2003): (i) existing policy frameworks and procedures; (ii) capacity building mechanisms for HIA; (iii) institutional infrastructure; and (iv) intersectoral collaboration for successful HIA implementation. The Asian Region has proven that sustained efforts on these parameters are a promising way to promote HIA practice on a large-scale, including developing countries in Southeast Asia (Harris-Roxas, 2011). In the African Region, however, all of these parameters are still literarily inexistent at a regional and national level. Consequently, the promotion of HIA practice in a large portion of the developing world, i.e. sub-Saharan Africa, is primarily depending on international institutions which have made a considerable effort in this regard over the past years as portrayed in more detail in chapter 5 of the present thesis: (i) development banks and other finance institutions from the private and public sector have adopted benchmarks for determining, assessing and managing social and environmental risks in project financing (Equator Principles Financial Institutions (EPFI), 2006; International Finance Corporation (IFC), 2006); (ii) the private sector has established guidance for the conduct of HIA in the extractive industry sector (International Petroleum Industry Environmental Conservation Association (IPIECA), 2005; International Council on Minerals and Metals (ICMM), 2010);

(iii) the WHO is working on guidance on how to manage public health impacts of natural resource extraction activities (WHO, 2009c, 2011b); and (iv) it is anticipated that also intergovernmental organisations such as the IMF and the World Trade Organization (WTO) will apply HIA as an accountability mechanism in the near future (O'Keefe and Scott-Samuel, 2010).

Although all these efforts are valuable contributions to the promotion of sustainable projects and policies in the developing world, they have major limitations. First, the set standards only apply to those that depend on financing from a finance institution that committed to health safeguard policies. This is critical in a competitive environment such as the extractive industry where the adherence to sustainable principles may impose an economic handicap (Krieger et al., 2010). Second, all of these efforts are based on best practice principles which are not a substitute for a legal basis (IFC, 2006). Consequently, they fall short to establish liability for negative health impacts caused by the proposals they support (Erlanger et al., 2008). Third, the provision of best practice principles and guidance on HIA alone is not sufficient when it comes down to the execution of HIA. Specific tools and methods that are adapted to the requirements of a given proposal and its context are still needed as shown in chapters 2-4 of this thesis, which employed the IFC guidelines as guiding framework (IFC, 2009). Fourth, the current international enforcement mechanisms have a strong focus on natural resource extraction activities, which appears reasonable based on the strong global demand in natural resources (Graedel and Cao, 2010; USEIA, 2010). However, in view of predictions regarding population developments and climate change, it will be of crucial importance that HIA practice goes far beyond the extractive industry sector and becomes common practice in the public sector in the developing world. Finally, all of these efforts have thus far failed to considerably influence the listed parameters for the strengthening of HIA practice at a regional and national level in the African Region (Caussy et al., 2003). Assuming that the international enforcement mechanisms will prove of value, this is leading to a worrying imbalance, as the limited capacity for conducting HIA in low- and middle-income countries will not be able to cope with the demand for HIA practice created by international institutions, let alone the demand in the public sector at national and regional level.

Hence, the top-down approach that was selected by the international community for the promotion of HIA in the developing world does not only have great potential but also serious constraints and its success will be limited due to missing national and regional HIA capacities. Consequently, if we truly want to promote HIA practice in the developing world in general, and the African Region in particular, we have to add to the current top-down approach a bottom-up strategy with the primary goal to build interest, excellence and capacity at regional and national levels. The WHO is uniquely placed for taking the lead in this process, ideally in close collaboration with HIA practitioners and academics, hereafter referred to as 'HIA community'.

6.4.1. The role of the WHO

The potential of HIA in the African Region was recognised by the WHO as early as in the year 2000, who initiated an inter-regional partnership meeting on the institutionalisation of HIA capacity building in Africa (WHO, 2001). It took eight more years until the potential of HIA in tropical countries was once more highlighted at the first Interministerial Conference on Health and Environment in Africa in 2008. At this conference the WHO announced an HIA capacity-building package, acknowledging that *"Africa is unique by virtue of the high levels of endemicity seen in a number of communicable diseases with strong links to the environment"* and that *"the development of natural resources, urban development and the expansion of transport systems and other infrastructure all precipitate changes to environmental and social determinants of health"* (WHO, 2009d). Consequently, the WHO started to develop guidance with a particular focus on public health impacts of industrial development projects (WHO, 2009c, 2011b). However, it is currently difficult to say how much has happened in terms of capacity building on the ground but experiences made in the frame of the current thesis showed that knowledge about HIA was inexistent or at rudimentary levels at involved Ministries of Health (MoH).

With the establishment of a thematic working group for HIA by the WHO Western Pacific Regional Office (WPRO) with its member countries, a body of well over 1,000 HIA practitioners was formed across the Asian Region (Harris-Roxas, 2011; WHO WPRO, 2011). It appears that such a leading institution is exactly what is missing in the African Region to make a start in the development of HIA capacities. It is thus strongly recommended that the WHO sets the establishment of a regional competence centre in HIA as a priority for the

African Region with the primary goal to increase awareness of, and create interest in, HIA as an approach for healthy public policy. This will trigger demand for HIA at national level and thus create its own dynamic for strengthening of HIA practice. However, true interest is generally built on practical examples and not on theoretical frameworks. To date, a serious constraint for the promotion of HIA in the developing world are the little references that are available: 7 out of 61 examples of HIA on the WHO website derive from developing countries, which have a considerable overlap with the 19 articles that deal specifically with HIA of policies, programmes or projects in the peer-reviewed literature, most of which are not open-access publications (WHO, 2011c). Hence, the available evidence-base for the value and practicability of HIA in tropical regions is limited to just a few examples. Furthermore, experience gained in HIA practice in the northern hemisphere is often not directly applicable to a developing country context. For example, the cost-effectiveness of HIA in an environment where straightforward low-cost interventions can make a real difference has to be challenged, especially when it is carried out by expensive international consultants. Hence, the primary mission of the WHO, to create interest in HIA, is hindered by considerable weaknesses in the evidence on benefits, pitfalls and practicability of HIA in the developing world and this is where the HIA community has to become more active.

6.4.2. The role of the HIA community

When HIA emerged as a new tool in the 1990s, Scott-Samuel recognised (1998): *"Good methodology results in methods appropriate to what is being studied; it is not therefore possible to prescribe one ideal method for appraising the broad range of health relevant public policy. What can be said is that multi-method approaches are likely to be required, and that these will usually be both qualitative and quantitative, multi- and inter-disciplinary."* This prediction turned out to be true and led to considerable diversity in HIA practice, resulting in a great variety of HIA guidance documents that has emerged over the past decade (Harris-Roxas and Harris, 2011; WHO, 2011d). Independent of whether the guidance documents were developed specifically for industrialised countries, or claim a more global validity, they were almost uniquely developed by people from industrialised countries (Utzinger, 2004). Consequently, they are, to a great extent, built on evidence and experience gained in the northern hemisphere. In view of the different realities of high- and low-income countries, which are unambiguously reflected by the burden of disease and major health risk factors (see Table 6.1 and 6.2), this is critical. For example, a HIA methodology that is based on the social determinants of health model has its limitations in the context of HIA of industrial development projects in a tropical country setting (Krieger et al., 2010). On the other hand, the social determinants of health as guiding framework for HIA may outgrow the strengths it has in high-income countries when applied in the context of urbanisation or policy planning in developing countries. The same applies for data collection, management and analysis tools, which have to withstand different requirements in a tropical context with generally poor baseline health data (Winkler et al., 2010, 2011, 2012). This, in turn, leads to a diversification in HIA processes that are built on specific contexts as exemplified in Figure 6.5.

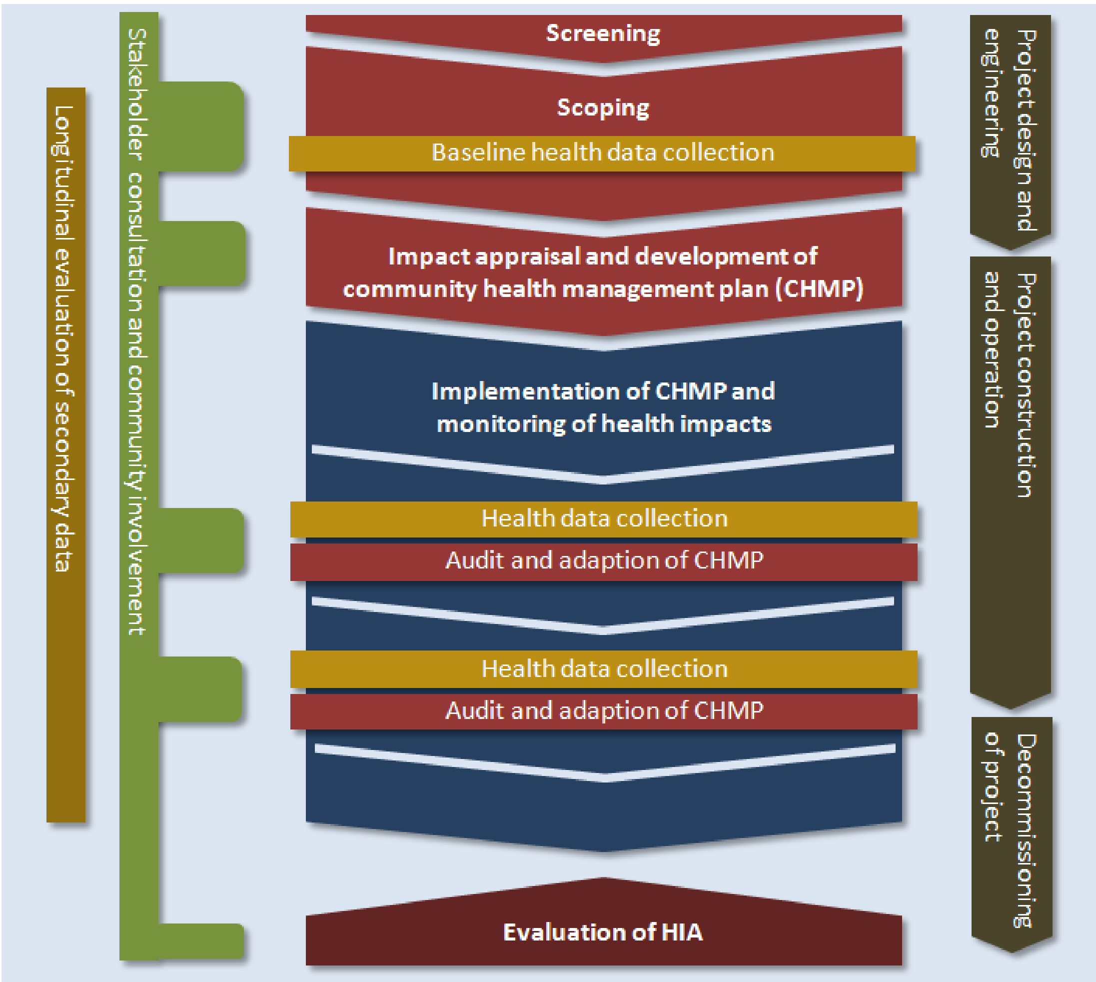


Figure 6.5: Roadmap for HIA of industrial projects in developing country settings.

These examples highlight that the HIA community does not only have to scrutinize and amplify the methodologies at hand but also become more clear about which methodology makes sense in what environment and for what purpose. However, this can only be done on the ground in developing countries, ideally, and importantly, in collaboration with local HIA practitioners. It is therefore proposed that the primary goal set by the HIA community is to advocate and expedite excellence in HIA that is integrated in academia and governments of developing countries. This requires active promotion of partnership with capacities from the academia and ministries by, for example, simply involving them in the process when performing HIA in their countries. True collaboration and mutual learning will allow to establish an enabling environment for further research on issues such as (i) cost-benefits of HIA in different contexts; (ii) HIA strategies for the translation of cognition on global climate change at regional scale down to a national and local level; (iii) HIA frameworks for urban planning in tropical countries; (iv) models and tools for the integration of developing country health systems into the HIA process; and (v) modelling of the linkage between project-related activities and affected communities, using geo-spatial analysis and Bayesian statistic.

In a long-term, the refinement of tools and methods on policy, programme and project level, combined with the promotion of excellence in HIA will not only strengthen the evidence-base on the value of HIA in the developing world, and consequently trigger interest, but also allow low-income countries to develop their own policy frameworks and procedures for HIA, which are adapted to the structure and legislation of local ministries as well as to the reality of tropical country environments and communities.

6.5. Conclusion

The systematic HIA approach that evolved within the frame of this 3-year PhD thesis has proven useful for HIA of industrial development projects in tropical country contexts. New methodological features for the assembling and processing of the best available evidence from different disciplines and methodologies in a transparent and rigorous process are an important contribution to the ethical use of evidence in HIA. Employment of participatory techniques at different stages of the process allows potentially affected communities and stakeholders to participate in the decision-making process and does thus promote democracy in HIA. With the goal to reduce inequity, the distribution of health impacts across different population groups is a central aspect throughout the presented methodology. Broad stakeholder engagement was considered essential for the development of sustainable mitigation measures and inducing interest and commitment in the HIA process from local authorities. Hence, the developed HIA methodology lends itself well to routine HIA of large-scale development projects in developing countries, especially since it has proven to be broadly applicable to different types of projects and environments.

From a global perspective, HIA practice in tropical countries is generally still poor, although there appears to be increasing interest in HIA in parts of the developing world, particularly in Southeast Asia. International enforcement mechanisms, deriving from the finance sector and extractive industry, have shown a positive effect in HIA practice on project level, but their influence to build interest and local capacities for HIA in developing countries is limited. This is a serious constraint in regard to the increasing demand for HIA of industrial development projects, notably induced by the international enforcement mechanisms, as well as for the institutionalisation of HIA in the public sector at national level. The latter will become of particular importance in view of a growing world population, accelerating urbanisation and effects of global climate change, all of which have alarming potential for adverse health impacts in the developing world. It is therefore proposed that the WHO and the HIA community at large should make any efforts possible for further promoting HIA in the developing world. The primary goal should be to establish regional HIA competence centres that can serve as basis to advocate and expedite excellence and capacities that are integrated in academia and governments of developing countries.

This thesis represents an exemplary effort for the development of HIA methodologies that are fit for purpose in the developing world and the building up of interest in HIA. Consultation of, and close collaboration with, national and local health authorities, people working in the public health sector and community relation teams at project level triggered interest in HIA and led to an environment of knowledge transfer and mutual learning. The case study character of the presented methodology assists HIA practitioners form industrialised and developing countries to better understand the proposed approaches. Furthermore, an important contribution to the limited set of examples of HIA in developing country settings was made. However, in order to yield the full potential of HIA in developing countries, similar research efforts are needed on policy and programmatic level in different sectors.

6.6. References

Adler NE, Boyce T, Chesney MA, Cohen S, Folkman S, Kahn RL, Syme SL (1994). *Socioeconomic status and health: the challenge of the gradient*. American Psychologist 49: 15-24.

Alirol E, Getaz L, Stoll B, Chappuis F, Loutan L (2011). *Urbanisation and infectious diseases in a globalised world*. Lancet Infectious Diseases 11: 131-141.

Amigun B, Musango JK, Stafford W (2011). *Biofuels and sustainability in Africa*. Renewable and Sustainable Energy Reviews 15: 1360-1372.

Beaglehole R, Yach D (2003). *Globalisation and the prevention and control of non-communicable disease: the neglected chronic diseases of adults*. Lancet 362: 903-908.

Berkman L, Kawachi I (2000). *Social epidemiology*. New York, U.S.: Oxford University Press.

Bilgen S, Kaygusuz K, Sari A (2004). *Renewable energy for a clean and sustainable future*. Energy Sources 26: 1119-1129.

Birley M (2004). *HIA in developing countries*. In: Kemm J, Parry J, Palmer S, editors. Health impact assessment: concepts, theory, techniques, and applications. Oxford, UK: Oxford University Press pp. 363-375.

Braveman P, Tarimo E (2002). *Social inequalities in health within countries: not only an issue for affluent nations*. Social Science & Medicine 54: 1621-1635.

Brew-Hammond A (2010). *Energy access in Africa: challenges ahead*. Energy Policy 38: 2291-2301.

Brooks DR, Hoberg EP (2007). *How will global climate change affect parasite-host assemblages?* Trends in Parasitology 23: 571-574.

Butler D (2011). *Fukushima health risks scrutinized*. Nature 472: 13-14.

Caussy D, Kumar P, Sein UT (2003). *Health impact assessment needs in south-east Asian countries*. Bulletin of the World Health Organization 81: 439-443.

Climate and Health Council (2011). *Official website*. London, U.K.: The Climate and Health and Council [http://www.climateandhealth.org/; accessed: 9 May 2011].

Costello A, Abbas M, Allen A, Ball S, Bell S, Bellamy R, Friel S, Groce N, Johnson A, Kett M, Lee M, Levy C, Maslin M, McCoy D, McGuire B, Montgomery H, Napier D, Pagel C, Patel J, et al. (2009). *Managing the health effects of climate change*. Lancet 373: 1693-1733.

Dobson A (2009). *Climate variability, global change, immunity, and the dynamics of infectious diseases*. Ecology 90: 920-927.

Dye C (2008). *Health and urban living*. Science 319: 766-769.

EPFI (2006). *The equator principles*. London, U.K.: The Equator Principles Association [http://www.equator-principles.com; accessed: 9 May 2011].

Erlanger TE, Krieger GR, Singer BH, Utzinger J (2008). *The 6/94 gap in health impact assessment*. Environmental Impact Assessment Review 28: 349-358.

Ezzati M, Lopez AD, Rodgers A, Murray CJL (2004). *Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors*. Geneva, Switzerland: World Health Organization.

Ezzati M, Lopez AD, Rodgers A, Vander Hoorn S, Murray CJL, Comparative Risk Assessment C (2002). *Selected major risk factors and global and regional burden of disease*. Lancet 360: 1347-1360.

Ezzati M, Utzinger J, Cairncross S, Cohen AJ, Singer BH (2005). *Environmental risks in the developing world: exposure indicators for evaluating interventions, programmes, and policies*. Journal of Epidemiology and Community Health 59: 15-22.

Forbes N (2011). *Renewing support for renewables*. New York, U.S.: The New York Times.

Friel S, Marmot M, McMichael AJ, Kjellstrom T, Vagero D (2008). *Global health equity and climate stabilisation: a common agenda*. Lancet 372: 1677-1683.

Frumkin H, Hess J, Luber G, Malilay J, McGeehin M (2008). *Climate change: the public health response*. American Journal of Public Health 98: 435-445.

Godfrey R, Julien M (2005). *Urbanisation and health*. Clinical Medicine 5: 137-141.

Graedel TE, Cao J (2010). *Metal spectra as indicators of development*. Proceedings of the National Academy of Sciences of the United States of America 107: 20905-20910.

Graham H (2007). *Unequal lives: health and socioeconomic inequalities*. Maidenhead, U.K.: Open University Press.

Haines A, Wilkinson P, Tonne C, Roberts I (2009). *Aligning climate change and public health policies*. Lancet 374: 2035-2038.

Harris-Roxas B (2011). *Health impact assessment in the Asia Pacific*. Environmental Impact Assessment Review 31: 393-395.

Harris-Roxas B, Harris E (2011). *Differing forms, differing purposes: a typology of health impact assessment*. Environmental Impact Assessment Review 31: 396-403.

Hughes JL, Kemp LA (2007). *Building health impact assessment capacity as a lever for healthy public policy in urban planning*. New South Wales Public Health Bulletin 18: 192-194.

ICMM (2010). *Good practice guidance on health impact assessment*. London, U.K.: International Council on Minerals & Metals [http://www.icmm.com/page/35457/good-practice-guidance-on-health-impact-assessment; accessed: 9 May 2011].

IEA (2003). *World energy investment outlook 2003*. Paris Cedex, France: International Energy Agency.

IFC (2006). *Performance standards*. Washington, D.C., U.S.: International Finance Corporation [http://www.ifc.org/ifcext/sustainability.nsf/Content/PerformanceStandards; accessed: 9 May 2011].

IFC (2009). *Introduction to health impact assessment*. Washington, D.C., U.S.: International Finance Corporation [http://www.ifc.org/ifcext/sustainability.nsf/Content/Publications_Handbook_HealthImpactAssessment; accessed: 9 May 2011].

IMF (2010). *World economic outlook: rebalancing growth*. Washington, D.C., U.S.: International Monetary Fund.

IPCC (2007). *Climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change*. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, eds. Cambridge, U.K.: Cambridge University Press.

IPIECA (2005). *A guide to health impact assessment in the oil and gas industry*. London, U.K.: International Petroleum Industry Environmental Conservation Association [http://www.ipieca.org/system/files/publications/HPI.pdf; accessed: 9 May 2011].

Jamison DT, Feachem RG, Makgoba MW, Bos ER, Baingana FK, Hofman KJ, Rogo KO (2006). *Disease and mortality in sub-Saharan Africa, 2nd edition*. Washington, D.C., U.S.: The International Bank for Reconstruction & Development and The World Bank.

Jobin W (2003). *Health and equity impacts of a large oil project in Africa*. Bulletin of the World Health Organization 81: 420-426.

Karekezi S (2002). *Renewables in Africa: meeting the energy needs of the poor*. Energy Policy 30: 1059-1069.

Karl TR, Trenberth KE (2003). *Modern global climate change*. Science 302: 1719-1723.

Kjärstad J, Johnsson F (2009). *Resources and future supply of oil*. Energy Policy 37: 441-464.

Kline KL, Dale VH (2008). *Biofuels: effects on land and fire*. Science 321: 199-199.

Krieger GR, Balge MZ, Chanthaphone S, Tanner M, Singer BH, Fewtrell L, Kaul S, Sananikhom P, Odermatt P, Utzinger J (2008). *Nam Theum 2 hydroelectric project, Lao PDR*. In: Fewtrell L, Kay D, editors. Health impact assessment for sustainable water management. London, U.K.: IWA Publishing pp. 199-232.

Krieger GR, Utzinger J, Winkler MS, Divall MJ, Phillips SD, Balge MZ, Singer BH (2010). *Barbarians at the gate: storming the Gothenburg consensus*. Lancet 375: 2129-2131.

Lafferty KD (2009). *The ecology of climate change and infectious diseases*. Ecology 90: 888-900.

Lal R (2004). *Soil carbon sequestration impacts on global climate change and food security*. Science 304: 1623-1627.

Lerer LB, Scudder T (1999). *Health impacts of large dams*. Environmental Impact Assessment Review 19: 113-123.

Liaquat AM, Kalam MA, Masjuki HH, Jayed MH (2010). *Potential emissions reduction in road transport sector using biofuel in developing countries*. Atmospheric Environment 44: 3869-3877.

Lopez AD, Mathers CD (2006). *Measuring the global burden of disease and epidemiological transitions: 2002-2030*. Annals of Tropical Medicine and Parasitology 100: 481-499.

Marmot M (2005). *Social determinants of health inequalities*. Lancet 365: 1099-1104.

Marmot M, CSDH (2007). *Achieving health equity: from root causes to fair outcomes*. Lancet 370: 1153-1163.

Marmot M, Friel S, Bell R, Houweling TAJ, Taylor S, CSDH (2008). *Closing the gap in a generation: health equity through action on the social determinants of health*. Lancet 372: 1661-1669.

McMichael AJ (2000). *The urban environment and health in a world of increasing globalization: issues for developing countries*. Bulletin of the World Health Organization 78: 1117-1126.

McMichael AJ, Butler CD (2004). *Climate change, health, and development goals*. Lancet 364: 2004-2006.

Miranda JJ, Kinra S, Casas JP, Smith GD, Ebrahim S (2008). *Non-communicable diseases in low- and middle-income countries: context, determinants and health policy*. Tropical Medicine & International Health 13: 1225-1234.

Moore M, Gould P, Keary BS (2003). *Global urbanization and impact on health*. International Journal of Hygiene and Environmental Health 206: 269-278.

Murray CJL (1996). *Rethinking DALYs*. In: Murray CJL, Lopez AD, editors. The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020. Cambridge, U.S.: Harvard University Press pp. 1-99.

Murray CJL, Lopez AD, Jamison DT (1994). *The global burden of disease in 1990: summary results, sensitivity analysis and future directions*. Bulletin of the World Health Organization 72: 495-509.

Myers SS, Bernstein A (2011). *The coming health crisis*. Scientist 25: 32-37.

O'Keefe E, Scott-Samuel A (2010). *Health impact assessment as an accountability mechanism for the international monetary fund: the case of sub-Saharan Africa*. International Journal of Health Services 40: 339-345.

Parmesan C, Yohe G (2003). *A globally coherent fingerprint of climate change impacts across natural systems*. Nature 421: 37-42.

Patz JA, Campbell-Lendrum D, Gibbs H, Woodruff R (2008). *Health impact assessment of global climate change: expanding on comparative risk assessment approaches for policy making*. Annual Review of Public Health 29: 27-39.

Patz JA, Campbell-Lendrum D, Holloway T, Foley JA (2005). *Impact of regional climate change on human health*. Nature 438: 310-317.

Patz JA, Gibbs HK, Foley JA, Rogers JV, Smith KR (2007). *Climate change and global health: quantifying a growing ethical crisis*. EcoHealth 4: 397-405.

Prentice AM (2006). *The emerging epidemic of obesity in developing countries*. International Journal of Epidemiology 35: 93-99.

Raso G, Utzinger J, Silue KD, Ouattara M, Yapi A, Toty A, Matthys B, Vounatsou P, Tanner M, N'Goran EK (2005). *Disparities in parasitic infections, perceived ill health and access to health care among poorer and less poor schoolchildren of rural Côte d'Ivoire*. Tropical Medicine and International Health 10: 42-57.

Ruger JP, Kim HJ (2006). *Global health inequalities: an international comparison*. Journal of Epidemiology and Community Health 60: 928-936.

Scharlemann JPW, Laurance WF (2008). *Environmental science: how green are biofuels?* Science 319: 43-44.

Science News Staff (2011). *Nuclear power's global fallout*. Science 331: 1502-1203.

Scott-Samuel A (1998). *Health impact assessment: theory into practice*. Journal of Epidemiology and Community Health 52: 704-705.

Sheffield PE, Landrigan PJ (2011). *Global climate change and children's health: threats and strategies for prevention*. Environmental Health Perspectives 119: 291-298.

Spickett JT, Brown HL, Katscherian D (2011b). *Adaptation strategies for health impacts of climate change in Western Australia: application of a health impact assessment framework*. Environmental Impact Assessment Review 31: 297-300.

Spickett JT, Brown HL, Rumchev K (2011a). *Climate change and air quality: the potential impact on health*. Asia-Pacific Journal of Public Health 23: 37S-45S.

United Nations (2008). *The least developed countries report 2008: growth, poverty and the terms of development partnership*. Geneva, Switzerland: United Nations Conference on Trade and Development.

United Nations (2010a). *World population prospects: the 2008 revisions*. New York, U.S: United Nations, Department of Economic and Social Affairs.

United Nations (2010b). *World urbanization prospects: the 2009 revisions*. New York, U.S.: United Nations, Department of Economic and Social Affairs.

United Nations Population Fund (2007). *State of world population 2007: unleashing the potential of urban growth*. New York, U.S.: United Nations Population Fund.

USEIA (2010). *International energy outlook 2010*. Washington, D.C., U.S.: U.S. Energy Information Administration.

Utzinger J (2004). *Book review - Health impact assessment: concepts, theory, techniques, and applications*. Bull World Health Organ 82: 954.

Utzinger J, Keiser J (2006). *Urbanization and tropical health - then and now*. Annals of Tropical Medicine and Parasitology 100: 517-533.

Utzinger J, Wyss K, Moto DD, Yemadji N, Tanner M, Singer BH (2005). *Assessing health impacts of the Chad-Cameroon petroleum development and pipeline project: challenges and a way forward*. Environmental Impact Assessment Review 25: 63-93.

Varis O (2007). *Water demands for bioenergy production*. International Journal of Water Resources Development 23: 519-535.

Victora CG, Wagstaff A, Schellenberg JA, Gwatkin D, Claeson M, Habicht JP (2003). *Applying an equity lens to child health and mortality: more of the same is not enough*. Lancet 362: 233-241.

Viner RM, Coffey C, Mathers C, Bloem P, Costello A, Santelli J, Patton GC (2011). *50-year mortality trends in children and young people: a study of 50 low-income, middle-income, and high-income countries*. Lancet 377: 1162-1174.

Vohra S (2007). *International perspective on health impact assessment in urban settings*. New South Wales Public Health Bulletin 18: 152-4.

von Schirnding Y (2002). *Health in sustainable development planning: the role of indicators*. Geneva, Switzerland: World Health Organization.

WHO (2001). *Health impact assessment: harmonization, mainstreaming and capacity building.* Report of an inter-regional meeting on harmonization and mainstreaming of HIA in the World Health Organization and of a partnership meeting on the institutionalization of HIA capacity building in Africa, Arusha, 31 October-3 November 2000. Geneva, Switzerland: World Health Organization.

WHO (2008a). *The global burden of disease: 2004 update*. Geneva, Switzerland: World Health Organization.

WHO (2008b). *World health statistics 2008*. Geneva, Switzerland: World Health Organization.

WHO (2009a). *Global health risks: mortality and burden of disease attributable to selected major risks*. Geneva, Switzerland: World Health Organization.

WHO (2009b). *Protecting health from climate change: connecting science, policy and people*. Geneva, Switzerland: World Health Organization.

WHO (2009c). *Community health and development finance: six key entry points to identify and address community health and safety issues (draft)*. Geneva, Switzerland: World Health Organization.

WHO (2009d). *Health security through healthy environments. First interministerial conference on health and environment in Africa.* Geneva, Switzerland: World Health Organization.

WHO (2010). *The world health report 2010: health systems financing*. Geneva, Switzerland: World Health Organization.

WHO (2011a). *Global burden of disease*. Geneva, Switzerland: World Health Organization [http://www.who.int/healthinfo/global_burden_disease; accessed: 9 May 2011].

WHO (2011b). *Managing the public health impacts of natural resource extraction activities: a framework for national and local health authorities (discussion draft)*. Geneva, Switzerland: World Health Organization.

WHO (2011c). *Health impact assessment*. Geneva, Switzerland: World Health Organization [http://www.who.int/hia/en/; accessed: 9 May 2011].

WHO (2011d). *Health impact assessment: short guides*. Geneva, Switzerland: World Health Organization [http://www.who.int/hia/about/guides/en/; accessed: 9 May 2011].

WHO WPRO (2011). *Official website*. Manila, Philipines: WHO Regional Office for the Western Pacific [http://www.wpro.who.int/vietnam/sites/dhs/environment/; accessed: 9 May 2011].

WHO/CSDH (2008). *Closing the gap in a generation: health equity through action on the social determinants of health*. Geneva, Switzerland: World Health Organization.

Winkler MS, Divall MJ, Krieger GR, Balge MZ, Singer BH, Utzinger J (2010). *Assessing health impacts in complex eco-epidemiological settings in the humid tropics: advancing tools and methods*. Environmental Impact Assessment Review 30: 52-61.

Winkler MS, Divall MJ, Krieger GR, Balge MZ, Singer BH, Utzinger J (2011). *Assessing health impacts in complex eco-epidemiological settings in the humid tropics: The centrality of scoping*. Environmental Impact Assessment Review 31: 310-319.

Winkler MS, Divall MJ, Krieger GR, Schmidlin S, Magassouba ML, Knoblauch AM, Singer BH, Utzinger J (2012). *Assessing health impacts in complex eco-epidemiological settings in the humid tropics: modular baseline health surveys*. Environmental Impact Assessment Review 33: 15-22.

World Bank (1993). *World development report 1993: investing in health*. Washington, D.C., U.S.: The World Bank Group.

World Bank (2011). *How we classify countries*. Washington, D.C., U.S.: The World Bank Group [http://data.worldbank.org/about/country-classifications; accessed: 9 May 2011].

Yager TR, Bermúdez-Lugo O, Mobbs PM, Newman HR, Wilburn DR (2007). *2005 minerals yearbook: the mineral industries of Africa*. Reston, U.S.: U.S. Geological Survey.

Yang GJ, Gao Q, Zhou SS, Malone JB, McCarroll JC, Tanner M, Vounatsou P, Bergquist R, Utzinger J, Zhou XN (2010). *Mapping and predicting malaria transmission in the People's Republic of China, using integrated biology-driven and statistical models*. Geospatial Health 5: 11-22.

Zhao MS, Running SW (2010). *Drought-induced reduction in global terrestrial net primary production from 2000 through 2009*. Science 329: 940-943.

7. Appendix: project descriptions

Guyana Goldfields Project

The Guyana Goldfields Project consists of two distinct property locations; the Aurora and Aranka properties. These gold deposits are located in the Amazon rainforest, approximately 200 km upstream the Cuyani river from the capital city Georgetown. The project region has been an important artisanal mining area with an estimated 6,000 workers that live in various associated communities, particularly along the Aranka River, and produce 3-4 tonnes of gold per year. The project is currently in the feasibility phase and operations are centered on two exploration camps known as Aurora and Aranka camps. Due to the remote location of the gold deposits, the development of a robust and reliable infrastructure is a critical element for the success of the project, especially since it is the premiere project of its kind and may thus serve as a model for future mine developments in Guyana and elsewhere. Project plans include 31 km of new all-weather roads, a port facility, a permanent 1,200 ft airstrip and a 25 megawatt hydroelectric facility. With the goal to use the latest technology that is both environmentally and economically sound, the latter will be developed with guidance from the International Financial Corporation, which is currently sharing 50% of the cost of the different feasibility studies.

Source: Official website of Guyana Goldfields (www.guygold.com)

Aurora camp in the Amazon Rainforest

Randgold Resources Kibali Project

Randgold Resources is an Africa focused gold mining and exploration company. In the Democratic Republic of the Congo (DRC), the objective of Randgold is to develop the Kibali Project (former Moto Gold Project) in the north-eastern part of the country. The Kibali concession covers an area of 1.841 km^2 in a rich gold-mining region with large-scale mining undertaken mainly by Belgian interests, dating back to the 1950s. The project is held in a 50:50 joint venture between Randgold Resources and AngloGold Ashanti, which hold an effective 90% interest in Kibali Goldmines. The remaining 10% is held by a parastatal Congolese gold mining company. The Kibali Project development costs for the full-scale development phase were estimated at US$ 0.5 billion. Key project construction components include, open pits and underground mines, a process plant with the capacity of 2.8 million tonnes per year, power generation facilities including a 20 megawatt hydroelectric station and the construction of new project roads (total length ~160 km), linking the project to the Ugandan border. The project will become an important employer in the region not only during the 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. However, the exact human resource requirements for the construction and operation of the project have yet to be determined.

Source: Official website of Randgold Resources (www.randgoldresources.com)

Gorumbwa village in the Kibali Project region

Barrick Bulyanhulu Goldmine

Barrick is the gold industry leader, with a portfolio of 26 operating mines and advanced exploration and development projects located across the five continents, 4 of which are operating on the Africa continent in northwest Tanzania. The Bulyanhulu Goldmine is located approximately 50 km south of Lake Victoria in north-western Tanzania, at an elevation of 1,200 m above sea level. It is a deep shaft mine that started its operations in March 2001 as Barrick Gold's first project in Tanzania. The mine has an anticipated life of mine until approximately 2032. The project is surrounded by 8 immediately impacted villages and presently approximately 40,000 people live in the vicinity of the Bulyanhulu Goldmine. As part of the mine development, two housing schemes for the project workforce and their dependents were constructed, where currently about 500 residents have their primary residence, approximately 40% of whom are expatriates. The majority of the Tanzanian workforce is spread between the housing schemes and the surrounding villages.

Source: Official website of Barrick Gold (www.barrick.com)


Housing scheme constructed by Bulyanhulu Goldmine

Barrick Buzwagi Goldmine

The Buzwagi Goldmine is located in Kahama District, Shinyanga Region, in northwest Tanzania. The project is approximately 6 km east of Kahama Town (population ~36,000), at about 100 km west of the town of Shinyanga and 120 km south of Mwanza. The Buzwagi Goldmine is Barrick's the second largest mining operation in Tanzania which will become the largest single open pit in the country. Gold exploration started in 1995 and in 2004 the project moved into the development phase. In May 2009, Barrick announced the first gold pour at Buzwagi Goldmine. The project is designated for closure in 2024. The mine includes a mining area, an accommodation area and a 200 m wide buffer zone around the mine. The construction of the mine led to the resettlement of 540 households belonging to the three villages Mwendakulima, Chapulwa and Mwime. The resettled households were hosted by the same communities. Mwendakulima is the most populated village with more than 2,000 inhabitants.

Source: Official website of Barrick Gold (www.barrick.com)

Buzwagi Goldmine near Kahama Town in Tanzania

Barrick Tulawaka Goldmine

The Tulawaka Goldmine is located within the Lusahunga Ward of Biharamulo District, within Kagera Region, in northwest Tanzania. The project started with exploration in 1998 and commenced with the construction of the mine in 2004, which was fully operational in 2005. The mine was supposed to have a relatively short life time of only 5 years and thus the mine closure was planned for 2011. However, as new gold deposits were discovered, it is currently uncertain when the mine will come to closure. The mine site is completely surrounded by wooded land (Biharamulo Forest Reserve) and relatively isolated from other human settlements or land users. Mavota is the nearest village to the mine (5 km from site) with a population of almost 6,000 people living in a very rural and scattered area. Further communities live in the villages of Kabagole and Nyantakara, which are at about 25km from site, and the small town of Runzewe (~30 km from site). For the Tulawaka Goldmine an isolationist approach was chosen with all personnel residing on camp to minimise impacts of the mine site upon the community. The community outreach programme was somehow the only direct impact of the mine on the communities and had per aim to implement long term sustainable health and educational initiatives.

Source: Official website of Barrick Gold (www.barrick.com)

Tulawaka Goldmine mining camp

Barrick North Mara Goldmine

The North Mara Goldmine is located in north-western Tanzania, 100 km east of Lake Victoria, and 20 km south of the Kenyan border. It is part of Tarime District in the Mara Region. The North Mara mine was acquired by Barrick in 2006 as a result of the Placer Dome acquisition. The project consists of three open pit deposits, the Gokona pit, the Nyabirama pit, and the Gokona-Nyabigena pit. The open pits are conventional hard rock operations with drills, hydraulic shovels and mechanical drive haul trucks. Ore is processed through crushers, an open semi-autogenous circuit mill and a closed circuit ball mill. The crushed ore is treated via cyanidation (carbon in leach) and gravity circuit, followed by electrowinning and gold refining to doré on site. An estimated 72,000 people reside in the 13 villages that are considered impacted by the project. In general, the people in the project area are predominantly subsistence farmers and households are scattered over a wide area. However, three of these villages are more urbanised and are densely populated. These are Nyangoto, Kewanja and Nyamwaga and are all located in close proximity to the project. Nyangoto is the largest settlement. All the villages in proximity of the North Mara Goldmine were and are still affected by resettlements during the project developments.

Source: Official website of Barrick Gold (www.barrick.com)

Open pit of North Mara Goldmine

Rio Tinto SIMFER SA Simandou Iron Ore Project

The Rio Tinto Simandou Iron Ore Project is a world-class iron ore exploration and mining project located in Guinea's 'Guinée Forestière' and 'Haute Guinée' regions. The project will require significant infrastructural development and has a number of key future operational areas. The first is the mine site development at Simandou, a 110 km long mountain range at an altitude up to 1,650 m above sea level, which is located in the south-eastern portion of Guinea; about 550 km from the capital city Conakry. The other areas include the construction of a 700 km railway line from the mining concession to a planned deep-water port south of Conakry. Studies completed to date estimate that an up-front capital investment of at least US$ 6 billion will be required to permit commercial levels of production. For the Simandou project, Rio Tinto, a British-Australian multinational mining and resource company, is partnered with the International Finance Corporation, which holds a five percent stake in the project. The total workforce has been predicted to exceed 10,000 people for the construction of the mine, rail and water port, with some 4,500 full-time jobs during the project's operational phase. At an estimated production rate of over 70 million tonnes per annum over a 50-year period, the Simandou mine is predicted to generate considerable taxes and royalties to the Government of the Republic of Guinea and contribute to a regional development fund.

Source: Official website of the Rio Tinto Simandou Project (www.riotintosimandou.com)

Simandou mountain range

Rio Tinto Deep-Water Port Development

As part of the Simandou Iron Ore Project, Rio Tinto is planning to develop a deep-water port 40 km south of Conakry, in Forécariah District. The development will include a stockyard (~600 ha) for the iron ore that will arrive via the 700 km railroad from the Simandou mine and a conveyor (~25 km) that will cross the island of Kaback to the deep-water port. Kaback Island is populated by several independent villages, which are densely developed along three parallel roads that cross the island from south to north. On the eastern side of the inhabited belt, small hamlets still survive in patches of higher grounds with oil palms, and along the roads. These hamlets are numerous, but most are quite small, between <5 to 15-20 houses in the biggest ones. The land used to be more occupied, and villages have been abandoned during the last 100 years. Agriculture is the main livelihood source in Kaback area with rice as the major crop. Also horticulture of market garden crops, such as red pepper, eggplant, water melon, okra, and others, has become a major source of income which can be practiced using relatively small surfaces of high quality land. Though close to the sea, channels and rivers, only a minority of the households practices fishing. This is different in Matakang, a village at the tip of the island where fishing is the major source of income. The region is rich in oil palms, and oil extraction can be frequently observed in the villages.

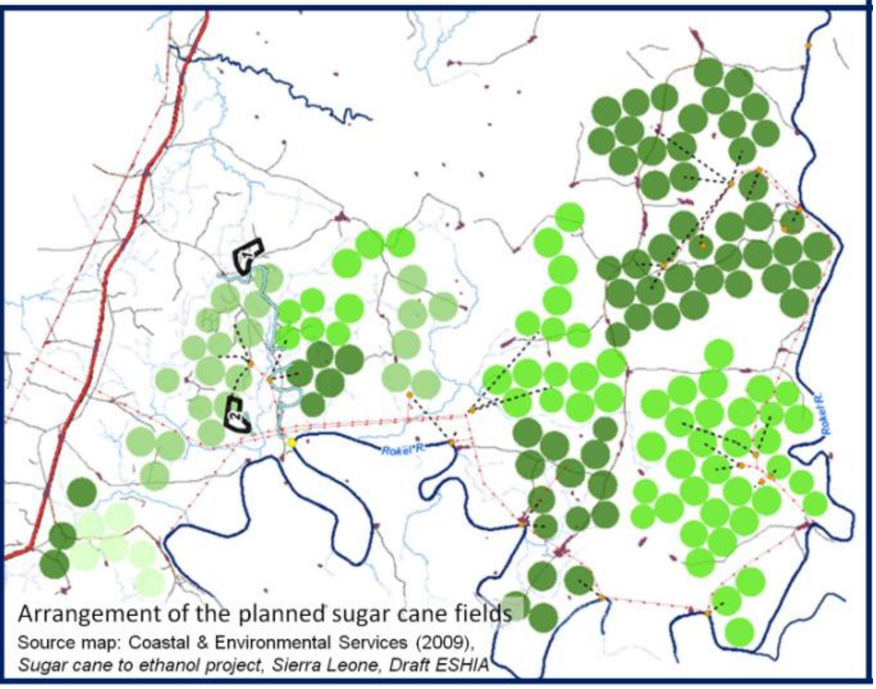
Source: Official website of the Rio Tinto Simandou Project (www.riotintosimandou.com)

Village along the road on Kaback Island

Addax Bioenergy Project

Addax Bioenergy, a division of the Swiss-based energy corporation Addax & Oryx Group, intends to develop an agricultural and renewable energy project in Sierra Leone to produce fuel ethanol and electricity. The Addax project is to a large extent financed by European Development Finance Institutions and the African Development Bank and applies international best practice standards. The project will consist of a sugarcane plantation, ethanol distillery and biomass power plant. The project development area is located approximately 15 km southwest of the town of Makeni in the Chiefdoms of Makari Gbanti and Bombali Shebora in the norther Province of Sierra Leone. The project will be developed in an area covering about 14,100 ha, including planted areas of total 10,100 ha. The sugar factory will be capable of processing up to 4,800 tons of cane per day, producing sugar juice as the primary feedstock for a 350 m^3 per day fermentation distillery (90,000 m^3 of ethanol per annum) and a 30 MW co-generation plant. The factory, distillery and the sugarcane estates irrigation system will be powered by the factory's own power-plant, which will be fuelled with cane residues. The power-plant will be designed to generate 30 MW of power, of which up to 15 MW will be fed into the national grid through the nearby power line from the Bumbuna Hydroelectric Project. The denatured anhydrous ethanol will then be transported by road to the Petroleone Port Terminal in Freetown for exportation to Europe.

Source: Official website of the Addax & Oryx Group (www.addax-oryx.com)



Arrangement of the planned sugar cane fields
Source map: Coastal & Environmental Services (2009), *Sugar cane to ethanol project, Sierra Leone, Draft ESHIA*

Zanaga Iron Ore Project

The Zanaga Iron Ore Project is currently in the feasibility phase, studying the potential for the management, development and construction of a world-class iron ore mine and related processing, rail and port infrastructure. Zanaga Iron Ore Company Limited is the owner of 50% less one share interest in the Zanaga Iron Ore Project based in the Republic of Congo through its joint venture partnership with Xstrata, a major global diversified mining group. It is expected that the iron ore mined at the Zanaga Project will be processed on site and then transported by train to the Group's proposed port site near Pointe Noire. The proposed project site is located in the Lekoumou Province of the Republic of Congo approximately 300 km from Pointe Noire and 250 km from Brazzaville as the crow flies. The project lease extends over an area of approximately 4,000 km^2 up to the international border with Gabon. The identified resource extends along a ridge of approximately 40 km in length. The project is currently estimated to involve over US$ 5 billion of capital investments, for a mine life of potentially over 20 years producing an estimated 30-45 million tonnes per annum.

Source: Official website of Zanaga Iron Ore Company Ltd. (http://zanagairon.com)

View over the Zanaga Project area

Ashanti Gold Fields Kilo Mongbwalu Project

Ashanti Gold Fields Kilo (AGK), a subsidary of the global mining company AngloGold Ashanti, is undertaking a feasibility study for the Mongbwalu Project located near Mongbwalu Town in the north-eastern Democratic Republic of the Congo (DRC). AGK holds mining permits for a 5,487 km^2 area within the formerly known Concession 40 and has committed the project to being governed by DRC legal requirements. Furthermore, the project applies AngloGold Ashanti and international best practice standards. The project involves underground mining and processing of ore to produce unrefined gold in an area that has been degraded by a long history of mining. The feasibility study is focusing initially on a five-year production life, and the potential exists to extend the life thereafter. Additional feasibility studies will therefore be required for longer-term mining. The mine will involve an underground shaft, a processing plant, workshops and storage facilities, a tailings storage facility, a waste rock dump, housing facilities, water and energy supply, improved access roads and a helicopter landing pad. A major concern related to the project development is the potential for resettlement and displacement, particularly of artisanal miners, which may be forced to move with no clear substitute to their current livelihood activities.

Source: Official website of SRK Consulting, Africa (www.srk.co.zu)

Artisanal mining activities near Mongbwalu Town

8. Curriculum vitae

PERSONAL DATA

Full name:	**Mirko Severin Winkler**
Nationality:	Swiss
Address:	Oetlingerstrasse 151 CH-4057 Basel Switzerland
Tel.:	+41 79 455-8032
Email:	mirko.winkler@gmx.net mirko.winkler@unibas.ch mwinkler@newfields.com mwinkler@shapeconsulting.org

Languages:	German (mother tongue), English and French (excellent oral and written), Portuguese and Spanish (fluent), Italian (basic)
Software:	Microsoft Word/Excel/Power Point/Visio, EndNote 9, ArcGIS, AutoCAD, Adobe Photoshop, SPSS 14, R, STATA 9, Mind Manager, as well as some other specific software programmes
Present employer:	Swiss Tropical and Public Health Institute / NewFields LLC / SHAPE Consulting Ltd.

EXPERIENCE SUMMARY

Trained in environmental sciences (MSc ETH), epidemiology (PhD) and clinical tropical medicine (DTM&H), Mirko Winkler is a research associate at the Swiss Tropical and Public Health Institute. Mirko pursues research on health impact assessment of large infrastructure development projects in the developing world. In the frame of a public–private partnership Mirko works at the same time as a consultant for NewFields LLC (United States) and SHAPE Consulting Ltd. (South Africa).

Mirko is experienced in planning and implementing health impact assessments in developing country settings, including epidemiological data collection and analysis in the frame of baseline health surveys. Furthermore, he has experience in the field of medical entomology and vector control strategies, parasitology, sanitation standard operating procedures, health facility assessments and good clinical practice. He is currently involved in health impact assessments in Côte d'Ivoire, Democratic Republic of the Congo, Guyana, Mozambique, Republic of Guinea, Republic of the Congo, Sierra Leone, United Republic of Tanzania and Zambia.

EDUCATION

2011	PhD in Epidemiology (6/2008-5/2011); Swiss Tropical and Public Health Institute (Swiss TPH)/University of Basel, Basel, Switzerland Thesis: Assessing health impacts in complex eco-epidemiological settings in the humid tropics (Supervision: Prof. Dr. Jürg Utzinger, Swiss TPH; Prof. Dr. Gary Krieger, NewFields; and Dr. Mark Divall, NewFields)
2011	Diploma in Clinical Tropical Medicine; Gorgas Memorial Institute of Tropical and Preventive Medicine, Lima, Peru/The University of Alabama at Birmingham, Birmingham, U.S.
2008	MSc in Environmental Sciences (Major: Biomedicine and Human-Environment Systems); Swiss Federal Institute of Technology Zurich (ETHZ), Zurich, Switzerland Thesis: Efficacy of long-lasting insecticide for treating nets (ICON® MAXX) in the laboratory at Côte d'Ivoire (Supervision: Prof. Dr. Jürg Utzinger, Swiss TPH; Prof. Dr. Manfred Kopf, ETHZ; Dr. Benjamin Koudou, Centre Suisse de Recherches Scientifiques en Côte d'Ivoire (CSRS))
2002	Cours des Mathématiques Spéciales (CMS) at the Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland
1996-2000	Civil engineering draftsman and CAD technologist, WGGSP Engineering Consultants SIA/ASIC, Basel, Switzerland

EMPLOYMENT HISTORY

Since June 2011	Research fellow in Epidemiology at Swiss TPH/University of Basel, Basel, Switzerland
Since February 2008	Consultant of NewFields LLC, Denver, U.S. and SHAPE Consulting Ltd., Pretoria, South Africa, specialized on health impact assessments in developing country settings, including epidemiological data collection and analysis in the frame of baseline health surveys
2008-2011	PhD fellow in Epidemiology at Swiss TPH/University of Basel, Basel, Switzerland, pursuing a 3-year PhD programme in epidemiology under the supervision of Prof. Dr. Jürg Utzinger, Prof. Dr. Gary Krieger
2003-07	Temporary employee at the medical faculty in the field of sport sciences at the University of Basel, Switzerland
2005-06	Temporary employee as civil engineering draftsman and CAD technologist, WGGSP Engineering Consultants SIA/ASIC, Basel, Switzerland

CONSULTANCIES

2011

Rio Tinto Simandou Project, Guinée – conducted the health impact assessment scoping study for the proposed 700 km railway development project with results that will feed into the comprehensive health impact assessment and the development of a community health management plan.

Rio Tinto Simandou Project, Guinée – directed and project managed the baseline health survey in the zone of influence of the proposed deep-water port site, covering 8 different sentinel sites in the local communities.

Barrick Tulawaka Goldmine, Tanzania – project manager of the baseline health survey in the project region, covering 8 different sentinel sites in the local communities.

First Quantum Minerals Limited (FQML) Trident Project, Zambia – directed and managed the baseline health survey in the project region, covering 11 different sentinel sites in the local communities.

Guinea Alumina Project, Guinée – conducted a health impact assessment scoping study for the proposed port site with results that will feed into the comprehensive health impact assessment and the development of a community health management plan.

2010

Addax Bioenergy, Sierra Leone – designed, planned and managed the baseline health survey in the project region, covering 8 different sentinel sites in the local communities.

Rio Tinto Simandou project, Guinée – conducted a health impact assessment scoping study for the proposed port site with results that will feed into the comprehensive health impact assessment and the development of a community health management plan.

AngloGold Ashanti Mongbwalu project, Democratic Republic of the Congo – supported the health impact assessment including participatory data collection in the communities and local health facilities.

Kibali Goldmines, Democratic Republic of the Congo – designed, planned and managed the baseline health survey of the communities in the project region, covering 11 different sentinel sites.

Rio Tinto Simandou project, Guinée – designed, planned and managed the baseline health survey of the communities around the concession area of the proposed mining project, covering 14 different sentinel sites.

MPD Congo, Republic of Congo – conducted a health impact assessment scoping study with results that will feed into the comprehensive health impact assessment.

Addax Bioenergy, Sierra Leone – planned and carried out the health impact assessment including participatory data collection in the communities and local health facilities.

2009	**Rio Tinto Simandou project, Guinée** – conducted a health impact assessment scoping study for the proposed mining project with results that will feed into the comprehensive health impact assessment and the development of a community health management plan.
	IFC & Guyana Goldfields, Guyana – conducted a community health needs assessment and health facilities assessment in the frame of a feasibility study of a public-private partnership for medical outreach services.
	Millennium Challenge Corporation, Mozambique – review of baseline health status of communities in the Nacala Dam Study project area and assessment of potential project related health impacts within the frame of a health impact assessment.
	Barrick Goldmines, Tanzania – conducted 4 health impact assessment scoping studies at four different mine sites (North Mara, Tulawaka, Bulyanhulu and Buzwagi) with results that will feed into the comprehensive health impact assessment and the development of a community health management plan.
2008	**Moto Goldmines, Democratic Republic of the Congo** – planned and carried out the health impact assessment including participatory data collection in the communities and local health facilities.
	IFC & Guyana Goldfields, Guyana – developed data analysis methodology and tool for community health survey. Coordinated community health survey efforts and compiled results.
2007	**Syngenta Vector Control, Côte d'Ivoire** – evaluated the efficacy of a new long-lasting insecticide for treating nets (icon® Maxx) in the laboratory (project manager) and in an experimental site of M'Bé, Bouaké, central Côte d'Ivoire.

RESEARCH PUBLICATIONS

Winkler MS, Emile Tchicaya, Benjamin G Koudou, Jennifer Donzé, Christian Nsanzabana, Pie Müller, Akré M Adja, Andrew F Bywater & Jürg Utzinger (2011). Efficacy of ICON® Maxx in the laboratory and against insecticide-resistant Anopheles gambiae in central Côte d'Ivoire. Malaria Journal (under review).

Winkler MS, Divall MJ, Krieger GR, Balge MZ, Singer BH & Utzinger J (2011). Assessing health impacts in complex eco-epidemiological settings in the humid tropics: modular baseline health surveys. Environmental Impact Assessment Review 33: 15-22.

Winkler MS, Divall MJ, Krieger GR, Balge MZ, Singer BH & Utzinger J (2011). Assessing health impacts in complex eco-epidemiological settings in the humid tropics: the centrality of scoping. Environmental Impact Assessment Review 31: 310-319.

Hodges M, Koroma M, Baldé MS, Turay H, Fofanah I, Bah A, Divall MJ, **Winkler MS**, Zhang Y (2011). Current status of schistosomiasis and soil-transmitted helminthiasis in Beyla and Macenta Prefecture, Forest Guinea. Transactions of the Royal Society of Tropical Medicine and Hygiene 105: 672-674.

Krieger GR, Utzinger J, **Winkler MS**, Divall MJ, Phillips SD, Balge MZ, Singer BH (2010). Barbarians at the gate: storming the Gothenburg consensus. Lancet 375: 2129-2131.

Winkler MS, Divall MJ, Krieger GR, Balge MZ, Singer BH & Utzinger J (2010). Assessing health impacts in complex eco-epidemiological settings in the humid tropics: advancing tools and methods. Environmental Impact Assessment Review 30: 52-61.

ORAL PRESENTATIONS AND TEACHING

Winkler MS, Utzinger J. Health Impact Assessment. General Tropical Course 2011, Basel, Switzerland, November 2011.

Winkler MS. Modular baseline health surveys for health impact assessment in the developing world. IAIA 2011, Puebla, Mexico, Anticipated in June 2011.

Winkler MS, Utzinger J. Health Impact Assessment. General Tropical Course 2010, Basel, Switzerland, October 2010.

Winkler MS. Health impact assessment in complex eco-epidemiological settings: advancing tools and methods. 14th STI symposium, Basel, Switzerland, November 2009.

Winkler MS. An innovative approach for health impact assessment in the tropics. IAIA 2009, Accra, Ghana, Mai 2009.

Winkler MS, Utzinger J. Health Impact Assessment. General Tropical Course 2008, Basel, Switzerland, November 2008.